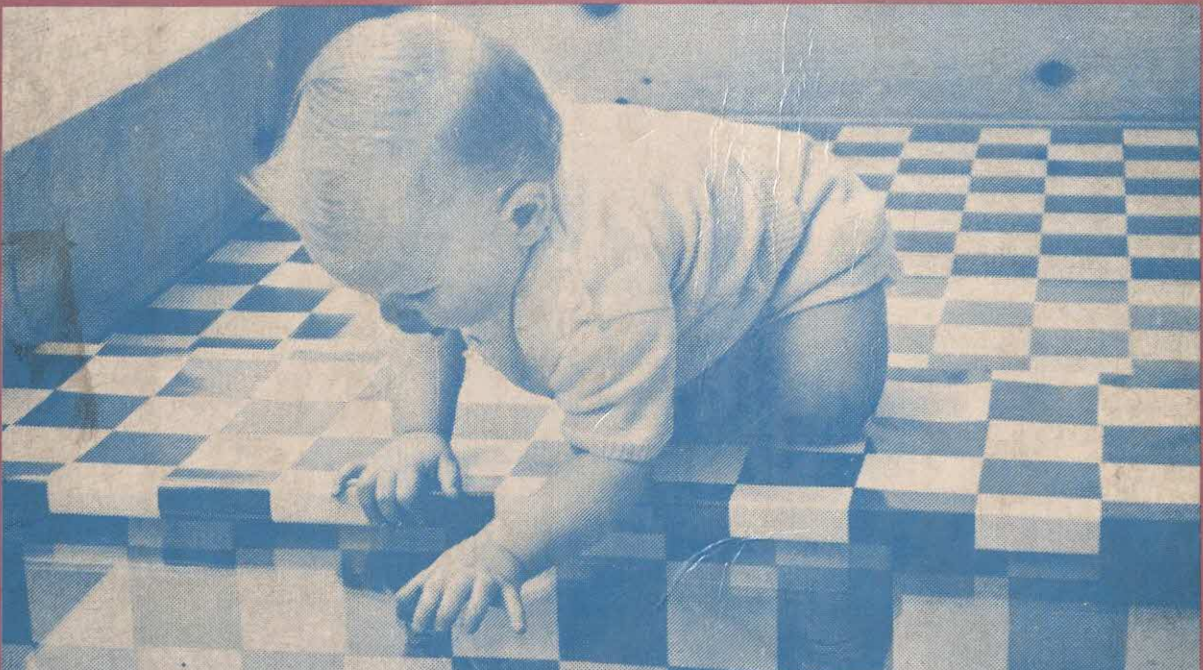
R. Michael Brown
Paul P. Cook

Introductory Psychology



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R. Michael Brown
Pacific Lutheran University

Paul P. Cook
Seattle University

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Chapter 1

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(Continued on p. 627)

Preface

This text is the result of the collaborative efforts of a psychologist (R.M.B.) and a biologist (P.P.C.). Our intent was to produce a comprehensive, accurate, well-integrated, and highly readable introduction to psychology, the science of behavior. To this end we have spent literally thousands of hours reviewing, evaluating, and organizing classic as well as recent psychological findings, theories, and applications. All of the major topics typically covered in a first course in psychology have been included.

A further aim was to include in our text information from other disciplines that is important for understanding behavior. Psychology does not stand alone in its concern for unraveling the mysteries of behavior; other disciplines also contribute to our knowledge of behavior directly, or provide information that is important, if not vital, to psychology. Examples include the role of genetics in understanding individual differences in behavior, of physiology in discovering the relationships between the brain and behavior, of physical anthropology in determining the possible origins of human behavior, of behavioral biology in gaining insight into the adaptive significance of various behaviors, and of history and philosophy in tracing the evolution of psychology itself. We wanted to present psychology not only in terms of what psychologists do but also as a broad area of knowledge to which many disciplines, especially the biological sciences, contribute.

Finally, we wanted to provide readers with a means of interrelating the often diverse topics that make up the discipline of psychology. As an undergraduate taking a first course in psychology, and later as an instructor teaching this course to a variety of students at different universities, I (R.M.B.) was struck by the lack of continuity evident in introductory psychology texts, even the very good ones. Judging from the comments of students and colleagues, my concern was not idiosyncratic. Of course, some discontinuity is expected, given the sometimes strikingly divergent conceptual models and research strategies employed in the various areas of psychology. Nevertheless, it seemed to me that neither instruction nor science is best served by ignoring concepts that could function as unifying principles.

In 1975 we discovered that two concepts — development (ontogeny) and evolution (phylogeny) — seemed to have enormous potential for interrelating topics in psychology and for gaining additional insight into behavior. We were co-teaching, for the first time, an interdisciplinary course on behavior, stressing psychological and biological perspectives. As the term progressed we found that we were learning a great deal from one another. It became increasingly clear that we could address a variety of behavioral phenomena from developmental and evolutionary perspectives. In some cases this meant understanding a behavior in a new way, with special emphasis on its dynamic and adaptive properties. In other instances the two perspectives generated questions and hypotheses that neither of us had entertained before. We were excited, not only by our discovery but also by the fact that other behavioral scientists were also beginning to emphasize development and evolution as fruitful conceptual frameworks for gaining novel and important insights into behavior. These two perspectives seemed to be natural, and scientifically respectable, candidates for establishing some degree of thematic continuity in an introductory psychology text.

Of course, there is nothing original about recognizing the explanatory and integrative potency of development and evolution for psychology. American psychology at the end of the nineteenth century and the beginning of the twentieth, particularly functional psychology, embraced both of these perspectives. This is especially clear in the writings of G. Stanley Hall and James Angell. Hall accorded genetics, evolution, and development a primary place in psychology. And Angell, in his presidential address to the American Psychological Association in 1906, argued for the acceptance of a biological approach to understanding how people adjust to the environment. Specifically, the mind was seen as a product of evolution, an adaptive mediator between people's needs and the demands of the external environment.

Nevertheless, it was behaviorism, not functionalism, that became the dominant force in American psychology, leaving behind many of the concerns of the functionalists (and others), including evolutionary and genetic considerations and the mind. From this perspective, developmental phenomena were understood primarily in terms of the accumulation of conditioned responses over time. This state of affairs characterized psychology for most of the first half of the twentieth century, especially in North America. During the 1960s, however, many psychologists appeared increasingly frustrated with a model of behavior that ruled out the mind as a proper focus for psychology and that ignored or downplayed the importance of biological influences. Since that time the character of psychology has undergone a significant facelift. Although retaining the rigorous methodology and emphasis on environmental variables characteristic of behaviorism, contemporary psychology has re-established mental activity as a central focus, and there is clearly an upsurge of interest in and activity related to the biological (physiological, genetic, evolutionary) and developmental bases of behavior.

Our inclusion of developmental and evolutionary perspectives reflects these growing trends within contemporary psychology and other sciences, as well as the aspirations of some of the early functionalists.

Major Features of the Text

Perspectives on Behavior

The most distinctive feature of the text is the use of developmental and evolutionary themes to help integrate traditional topics in psychology and to provide beginning-level students with important and timely perspectives on behavior. In spite of its thematic nature, the text is balanced and comprehensive; all major psychological topics and viewpoints are presented. The developmental and evolutionary perspectives, their relationship to psychology, and our use of them in the text are described in greater detail in Chapter 1 (Prologue).

Interdisciplinary Authorship

A psychologist–biologist author team is unique in the realm of introductory psychology texts, as far as we know. However, given the prominent influence of the biological sciences in shaping the discipline of psychology; the growing dependence of contemporary psychology on concepts and research findings from ecology, ethology, embryology, evolutionary theory, genetics, and physiology; and the thematic focus of our text, the inclusion of a biologist author seems highly appropriate.

R.M.B. received his doctorate in psychology from the University of North Carolina at Chapel Hill. He is currently a member of the psychology department at Pacific Lutheran University and is also affiliated with the metacognition program in psychology at the University of Washington. His areas of special interest and research activity include development and cognitive processes. He has taught the introductory course in psychology first as a graduate student at the University of North Carolina and later as a faculty member at Seattle University, Northern Michigan University, the University of Washington, and Pacific Lutheran University.

P.P.C. received his doctorate in biology from the University of California at Berkeley. He was a member of the biology department at Seattle University until 1984 when he retired. His areas of interest and research activity include animal behavior, entomology, genetics, ecology, evolution, and vertebrate natural history. He taught introductory biology for twenty years, as well as courses in animal behavior, genetics, and evolution.

Topical Organization and Comprehensive Coverage

Many introductory psychology texts organize the subject matter according to topic (for example, perception, learning, personality) *and* discipline (for example, social psychology, physiological psychology). We believe this kind of mixing detracts from efforts to achieve an integrated understanding of behavior. Moreover, it is inconsistent with an attempt to go beyond traditional disciplinary boundaries when discussing certain topics. Consequently, we have used a topical approach throughout.

We have included all of the topics typically covered in a first course in psychology. The twenty-two chapters are divided into seven units. Unit I consists of a prologue (Chapter 1) and two chapters containing important background material: the nature and history of psychology (Chapter 2) and research methods and statistics (Chapter 3). The chapters in Unit II are concerned with phylogenetic and ontogenetic origins of behavior. The in-depth treatment of principles of evolution (Chapter 4), heredity (Chapter 5), and developmental processes (Chapter 6) is, we think, unique among introductory psychology texts. The approach also provides important background knowledge for viewing behavior from developmental and evolutionary perspectives.

Specific applications of these principles are found throughout the text. For example, developmental aspects of cognition are found in the chapters on perception, memory, and conceptual behavior; evolutionary speculations concerning language appear in the chapter on communication and language; findings from behavioral genetics related to psychopathology are included in the chapter on abnormal behavior. The chapters in Unit III cover learning, including habituation and classical conditioning (Chapter 7), and instrumental and observational learning (Chapter 8). Those in Unit IV describe neurological and hormonal bases of behavior (Chapter 9) and motivation and emotion (Chapter 10). Unit V consists of four chapters on cognitive processes—sensation, perception, memory, and conceptual behavior. Much of this material is discussed from an information-processing perspective. Unit VI is a distinctive treatment of social behavior, combining traditional topics in social psychology with research, theory, and speculation from the areas of social development, behavioral biology, and anthropology. These chapters explore possible biological foundations for social behavior and culture (Chapter 15), characteristics of prosocial and agonistic behavior (Chapter 16), the processes of affiliation and bonding and sex differences in behavior that occur in a wide variety of cultures (Chapter 17), and the origins and development of language (Chapter 18). The book concludes with Unit VII—Individual Differences—emphasizing the dynamics of personality (Chapter 19), the concept and measurement of intelligence (Chapter 20), the various categories and possible causes of abnormal behavior (Chapter 21), and the therapeutic modification of behavior (Chapter 22).

Style of Presentation

In writing the text, our aim has been to produce a clear and interesting account of psychology. To this end we have had students as well as colleagues critique our writing, and we think this has resulted in a highly readable text. We have been careful to describe and define concepts clearly, to illustrate our points with concrete and interesting examples, and to avoid unnecessary jargon. We have also steered away from lengthy vignettes, "highlights" that disrupt the flow of the text, and other gimmicks that, although potentially entertaining, can be distracting and weak in information value.

Aids to Reading and Learning

Each unit, with the exception of Unit I (Introduction), begins with an overview that offers a preview of the material to follow. The overview also ties together the various chapters that comprise the unit. Each chapter begins with an outline that, with the exception of Chapter 1, is followed by a chapter preview that summarizes major points and stresses important themes. Placing a summary at the *beginning* of each chapter is not common practice in introductory psychology texts, but we believe it is helpful to preview the entire chapter briefly before becoming immersed in the details. This provides an organizational framework for reading and remembering the details and calls attention to important ideas.

In many of the chapters we have included *supplements* that contain examples and extended discussions illustrating or amplifying points made in the chapter, illustrations of behavioral applications, recent research that provides new or provocative insights into behavior, or discussions of controversial issues in psychology.

The glossary at the end of the book includes definitions of important terms that appear in each chapter in boldface type. A complete bibliography follows the glossary and precedes the name and subject indexes.

Instructor's Manual

The Instructor's Manual which accompanies the text is designed to help instructors in preparing to teach a course in introductory psychology. For each chapter there is a chapter outline, a list of terms and concepts, learning objectives, ideas for lecture topics and classroom activities, a list of appropriate films, and multiple-choice questions.

Acknowledgments

We extend our sincere appreciation to the following colleagues who reviewed the entire manuscript and contributed greatly to its development and refinement: James Berko, York University; Jay Braun, Arizona State University; Mark Covey, University of Idaho; Richard Day, McMaster University; Charles Leith, Northern Michigan University; Leonard Hamilton, Rutgers University; Spencer McWilliams, Winthrop College; William Pope, Mary Washington College; Donald Reutener, Smith College; L. Sandler, University of Manitoba; and Jane Veith, Washington State University.

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Seattle, Washington
October 1985

R. M. B.
P. P. C.

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UNIT I

Introduction

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1

Prologue

Describing Behavior: The *What* Questions

Immediate and Developmental Causes: The *How* of Behavior

Evolutionary Causes: The *Why* of Behavior

Applying Principles of Behavior

Perspectives on Behavior

This is a book about the behavior of living organisms, with special emphasis on human behavior. The term **behavior** refers to the activities of an organism, both those that are external and easily observed—**overt activities**—and those that are internal and must be inferred from observations—**covert** activities. Behavior ranges from the fairly automatic and simple movements that can be found in one-celled organisms such as bacteria or amoebas, to extremely flexible and complex operations such as hypothetical reasoning and language that may be solely the province of the human species. **Psychology** is, in fact, the scientific study of behavior, and those capacities and dispositions which make behavior possible or likely to occur.

Given the range and complexity of our subject matter, it is important that you know from the outset what we as authors have tried to accomplish in creating this text, how we have classified psychology in terms of its goals, and what perspectives we have stressed.

Our objective is to present psychology to you accurately and comprehensively, and in a manner that is both clear and interesting. As a step toward accomplishing this objective, we believe it is helpful to think of psychology as having three different but interrelated goals: to *describe* behavior, to *understand the causes* of behavior, and to use what we know about behavior—*apply principles* of behavior—for the betterment of humanity.

Describing Behavior: The *What* Questions

Psychologists ask and attempt to answer questions about behavior. Describing behavior is an attempt to answer the first kind of question we shall introduce—the *what* question. *What* questions ask about the content and form of behavior, and answering them represents the starting point in psychological research. To illustrate, consider human aggressive behavior. If eventually we hope to discover the reasons for aggression, and how to control or channel it appropriately, it is first essential to determine exactly what aggression is. That is, we need to define aggression (for example, as any act intended to hurt another), and then to observe and classify the various forms that it may take (hitting, kicking, pushing, insulting, and so on). Although this task may seem simple enough, a number of problems make it difficult for psychologists to agree on a definition of aggression in the first place. For example, should we consider a potentially harmful act aggressive if it is provoked by another, and therefore is retaliatory in nature? What about potentially harmful acts that occur in the interest of defending one's life or property, or in the process of securing food (as in hunting), or while participating in competitive sports? How much harm must result in order to identify an action as aggressive? And just how does one go about identifying the *intention* of a potential aggressor? Certainly, such obstacles to definition and description are not insurmountable, but they pose a serious challenge to the psychologist who attempts to answer *what* questions related to aggressive behavior. And aggression is no exception when considering the problems of gathering descriptive information. Throughout the text you will encounter various behavioral phenomena that carry with them similar problems of definition, phenomena such as intelligence, emotion, personality, motivation, stress, and conscious experience, to name only a few.

There are, of course, other illustrations of behavioral description which are more straightforward than the example of aggression, or the other examples mentioned above. For instance, we now have a great deal of data describing various behaviors and behavioral capacities which characterize newborn children and very young infants. The records of careful observers show that human infants are equipped with a variety of fully functional behaviors at birth. These include sucking in response to a nipple or other similar object placed in the baby's mouth, grasping of objects placed in the hand, turning the head in the direction of a light touch on the cheek (the rooting reflex), and making swimming movements when the infant is placed in water (the swimming reflex). We have also learned that many infants, even in the first days of life, perceive various visual

Aggression is a behavioral phenomenon that is difficult for psychologists to define, let alone understand. Which of the four scenes, if any, would you characterize as aggressive encounters?

patterns, the brightness of objects, movement, human speech sounds, and certain odors and tastes. The thorough descriptions of infant behaviors compiled over the past twenty-five years have given us an insight into infancy that is radically different from previous views. It has become clear that the newborn child perceives the environment in ways that are much more sophisticated than we ever imagined in the past. (For more on the remarkable sensory and perceptual capacities of infants, see Chapters 6 and 12).

Formulating and answering *what* questions such as these are essential activities for psychologists, and you will encounter a wealth of information derived from such endeavors in this text. However, describing behavior as an end in itself is rare indeed. For most psychologists, the truly exciting aspect of the science is its attempt to reveal the reasons for—the causes of—behavior.

Immediate and Developmental Causes: The *How* of Behavior

The vast majority of basic research studies in psychology ask *how* questions and try to answer them: that is, they search for immediate and developmental causes of behavior. *Immediate* causes are factors in the present environment or within the individual that affect, or can affect, behavior. *Developmental* causes are inherited (genetic) conditions and environmental events that influence growth and development from conception on, including the growth and development of behavior. Developmental causes span a longer period of time than immediate causes. They can affect the expression of a behavior temporarily or permanently. In a sense, developmental causes help establish the range and effectiveness of immediate causes of behavior. A child who is born with a hearing loss due to genetic or prenatal conditions will be denied access to the world of sound. In this instance, congenital deafness is a physical developmental factor which severely, and perhaps permanently, restricts the range and effectiveness of environmental stimuli to which the child can respond.

Our previous example of aggression nicely illustrates both kinds of causal analyses, immediate and developmental. Psychologists have indeed identified immediate factors in the external environment, and within the individual, that appear to be related causally to the expression of aggression. For example, simply observing other people aggress physically, whether in person, on television, or in the movies, can induce some individuals to act aggressively themselves (Liebert, Sprafkin, & Davidson, 1982). Clearly, this identifies an immediate *external* environmental event (witnessing others behave aggressively) which can affect the expression of aggression. Immediate factors *within* the individual have also been linked to aggressive behavior. For example, researchers studying the relationship of nervous system functioning to behavior have discovered that mild electrical stimulation of certain parts of the brain can produce aggression in the form of rage reactions and attacks on others in otherwise relaxed animals (Carlson, 1981). Although these findings come mainly from studies of nonhuman species, there is good reason to believe they may apply to humans as well (Mark & Ervin, 1970). Thus it would appear that the capacity for behaving aggressively is "wired in" to the nervous system.

Here then are two examples of immediate factors, external and internal, which have been linked to aggression through research. But what about developmental influences on aggression? Is there any reason to believe, for instance, that the likelihood of expressing aggression may depend upon the kinds of experiences a person has had, say, during early childhood? This is a very difficult *how* question to answer precisely; we do have some clues, but there is much debate over what they really mean. There is evidence to suggest, for example, that exposure to aggression on television may have more than immediate effects on children's behavior. Specifically, researchers have found a positive relationship between the amount of violence in third-grade boys' favorite TV programs and the levels of aggression the boys were reported to show, not only as third-graders but also later, as nineteen-year-olds (Eron, Huesmann, Lefkowitz, & Walder, 1972). In other words, boys who reported watching more violent TV as third-graders were more likely to be rated as aggressive third-graders, and also as aggressive young adults.

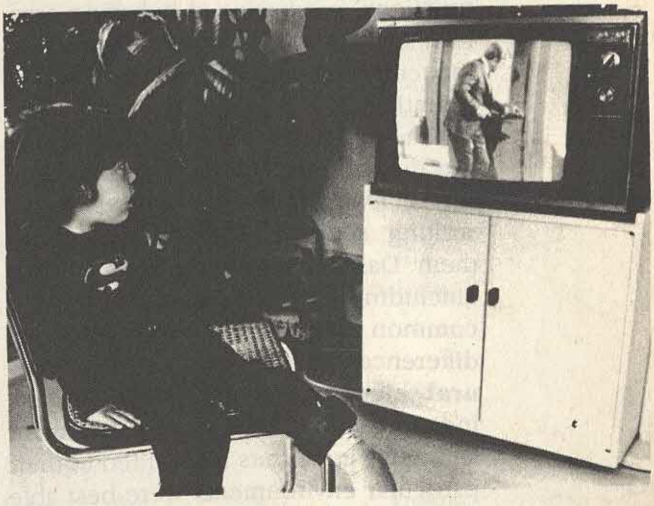
These findings raise the possibility that exposure to large amounts of TV violence may contribute to long-term as well as short-term changes in the aggressive behavior of certain individuals. However, these findings are not conclusive. It is possible, for example, that the cause-effect mechanism works another way; perhaps children who are already more aggressive prefer a good deal of violence in their TV fare. Precisely *how* the development of aggression is related to violent TV shows is still a matter of controversy.

To summarize: *how* questions search for immediate and developmental factors, both external and internal, that can influence behavior. Naturally, we are in a much better position to predict, understand, and if necessary change a behavior if we know how the behavior is influenced. You should note that sometimes the search for answers to these questions requires information that can be obtained only by consulting other scientific disciplines, such as biology, anthropology, and sociology. And of course the converse is true: other disciplines draw profitably upon psychology in achieving a better understanding of the phenomena they study. The need for interdisciplinary communication and cooperation becomes greater as we identify more and more aspects of the environment and the individual that can affect behavior.

Evolutionary Causes: The *Why* of Behavior

Why do people behave aggressively? Why are males generally more aggressive than females, even as two- and

Psychologists have shown that viewing aggressive episodes on television can induce some children to behave aggressively later when given the opportunity.



three-year-old children? Why does this sex difference hold up not only in humans but also in many other species in certain situations? These are but a few of the *why* questions about aggression, the example we have been using to illustrate the goals of psychology. *Why* questions address causes of behavior that go beyond the immediate or developmental; that is, they seek answers that can be found only by considering events that occurred during the development of a species, in contrast to those that occur during the lifetime of an individual (Alcock, 1979). Answers to *why* questions are sometimes called "ultimate" causes of behavior (Wilson, 1975). But the term *ultimate* is not meant to imply that such causes overshadow immediate or developmental influences in importance. Rather, you should think of ultimate causes as biological (evolutionary) forces that influenced our species and others, and that surely affected the varieties of behaviors, capacities, and dispositions we see in different species. These forces are "ultimate" in the sense that they have operated over a period of thousands or millions of years and have defined the particular structural and functional properties of behaving organisms. They are the most fundamental influences on behavior we can point to scientifically.

Charles Darwin's theory of evolution was meant to explain the amazing diversity of living organisms as well as the striking similarities that exist among them. Darwin theorized that all animals (including humans) evolved from a common ancestry, and that the species differences we see are the results of **natural selection.** According to this theory, individuals that inherited the structural and behavioral traits best suited to their particular environments were best able to survive and reproduce, thereby transmitting the successful traits to their offspring.

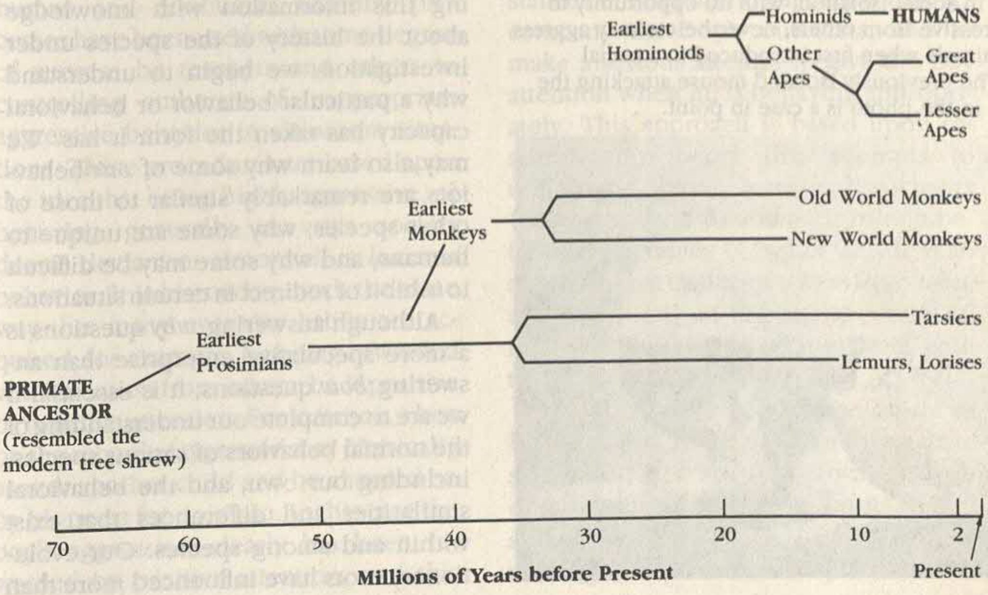
Over the years Darwin's ideas have been extended and modified somewhat, mainly due to research in **genetics,** the study of mechanisms of biological inheritance. However, his notion of adaptation through natural selection remains the central theme in contemporary thinking about evolution.

Let us return now to one of the *why* questions we posed at the beginning of this section: Why do people behave aggressively? To answer this or any other *why* questions requires more than a description of behavior (the *what* of behavior), and more than an understanding of the immediate and developmental forces that affect behavior (the *how* of behavior). Using the theory of evolution as a perspective, we need to know how behavior functions to adapt the individual to its natural surroundings, and as much as we can about the evolutionary history of the species to which the individual belongs. If we look to the theory of evolution, we can find clues regarding the possible origins of aggression in our species. However, we must transform our rather broad question into one that allows us to take advantage of the clues provided by evolution. The transformed question might be: Why *should* people be capable of aggressive behavior? In other words, are there, or were there ever, any adaptive advantages associated with behaving aggressively? And if so, how likely is it that the capacity for aggressiveness would have been preserved through natural selection? That is, how likely is it that aggressive capacities were influenced genetically—via the **genes,** the carriers of hereditary information—from generation to generation?

It seems clear that the capacity for behaving aggressively would have been essential for our prehuman and human ancestors. Anthropologists tell us that the human species evolved from a line of **primates** as shown in Figure 1.1. Major occupations of the hominids, our most immediate ancestors in this group, were hunting other animals and gathering food and materials for such things as shelter, clothing, and toolmaking. Behavioral biologists have shown that in a variety of species aggression functions to capture prey, ward off competitors, secure a mate, protect the young, and maintain social order. Given these facts, it seems reasonable to expect that the capacity for behaving aggressively, or the inclination to learn aggressive behavior, is and has been important for human survival in many situations. We can well imagine that early humans who were not aggressive would have had difficulty surviving even long enough to mate and leave offspring, let alone rear them to maturity. Compared to their timid peers, individuals who were aggressive when they had to be would have been more successful at transmitting their genetic characteristics to future generations, including any genes related to elements of aggression.

What we know about the history of our species makes a fairly convincing circumstantial case for the adaptive value of human aggressiveness. In addition, experimental evidence implicates genetic factors in aggressive behavior in a variety of species. For example, many animals can be bred for varying levels of aggressiveness (Fuller & Thompson, 1978). Moreover, rearing various animals such as mice, rats, gerbils, domestic chicks, various breeds of dogs, sheep, and rhesus monkeys in social isolation, with no opportunity to learn aggressive behavior from others, produces animals

FIGURE 1.1 Suspected primate ancestry of humans: Hunting and gathering were major occupations of the hominids.



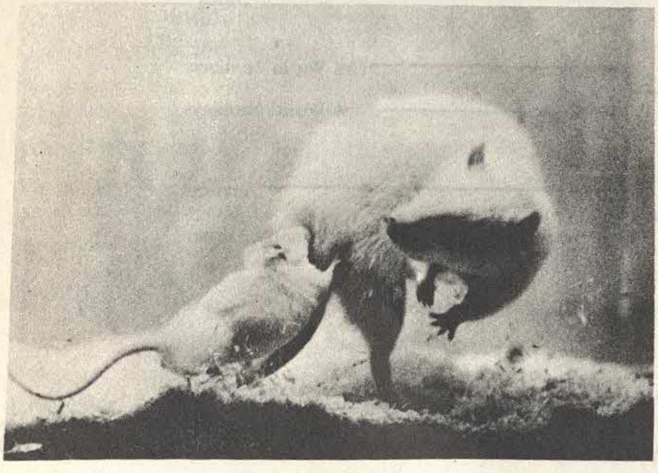
that tend to be much more aggressive than socially reared animals on their first encounters with members of their own or other species (Cairns, 1979).

Considering the evidence for a genetic influence on aggression in a variety of species, the apparent survival value of aggression, and the challenges faced by our ancestors, it is not unreasonable to expect that human aggression today arises *in part* from genetic programming inherited from our ancestors. It would also follow that individual differences we see in levels of aggressive behavior could be due *in part* to differences in genetic programming that exist among individuals. Of course, to say that aggression or any other behavior is influenced genetically in no way denies or diminishes the importance of the environment. It seems clear that aggressive behavior can be facilitated, inhibited, or redirected as a result of certain kinds of encounters with the environment.

It is important to note an essential difference between the search for evolutionary causes and the search for immediate and developmental causes. The former is less precise and requires much more guesswork than the latter. The search for immediate and developmental causes often is conducted through direct observation, which is not possible for evolutionary causes. And unless H. G. Wells' fantasies about time machines somehow come true, it is unlikely that this difference in precision will ever change. We simply cannot turn back the clock and directly observe the course of evolution and the ways it may have influenced behavior. This does not deter researchers in their search for evolutionary causes, however. We can, for example, directly observe behavior in the present, and the extent to which various behaviors help an organism adapt to the ecological demands of its environment. In addition, we may find that some behavioral variations are more likely to lead to survival and reproduction than others, and that genetic factors account in varying degrees for individual differences in certain behaviors. By combining this information with knowledge about the history of the species under investigation, we begin to understand why a particular behavior or behavioral capacity has taken the form it has. We may also learn why some of *our* behaviors are remarkably similar to those of other species, why some are unique to humans, and why some may be difficult to inhibit or redirect in certain situations.

Although answering *why* questions is a more speculative enterprise than answering *how* questions, it is essential if we are to complete our understanding of the normal behaviors of various species, including our own, and the behavioral similarities and differences that exist within and among species. Our evolutionary roots have influenced more than

Animals reared in social isolation, with no opportunity to learn to be aggressive from others, nevertheless may aggress against other animals when first introduced to a social environment. The previously isolated mouse attacking the much larger rat in the photo is a case in point.



our anatomy and physiology. Surely they have played a part in structuring our motivations, perceptions, learning, thinking, feelings, and social behaviors.

Applying Principles of Behavior

If you are like most beginning students of psychology, you are very much interested in the role psychology plays in helping people cope with the sometimes unusually intense frustrations that seem to be synonymous with everyday life in the closing decades of the twentieth century. You also may want answers from psychological theory and research that will contribute to your personal growth and self-awareness, and to better insight into the behavior of others.

In fact, you may already know that psychology and related behavioral and biological sciences have made important contributions to human welfare. For example, behavioral modification procedures developed from research into human and nonhuman learning processes have been used with some degree of success by teachers and others in controlling outbursts of inappropriate aggressive behavior in classroom situations. These procedures are based upon the idea that being highly aggressive, or behaving generally in ways society deems deviant or abnormal, is *learned* behavior. It is learned in much the same way that many everyday habits are acquired; for example, by being rewarded with attention from others, be it positive or negative attention. For instance, a boy on the school playground may physically assault another child and be cheered on by his peers for doing so. In this case the boy's aggression clearly has been rewarded by positive attention, and this may serve to increase the likelihood that such inappropriate behavior will occur in the future. It is also possible, however, that the boy's actions could meet with criticism from peers, teachers, or parents — negative attention. Although it may seem that negative attention should work to curb future instances of violence, this may not be the case, particularly for a child with a history of hyperaggressive outbursts. From such a child's perspective, negative attention may be preferable to no attention at all, and thus serves to reinforce the aggressive behavior.

According to the view that inappropriate aggression is a learned habit the remedy for this problem seems straightforward enough: find a way to get the boy to break the habit. One approach might be to punish the boy severely for aggressive episodes, though the use of frequent harsh punishment may elicit other unforeseen and undesirable reactions, such as fear and resentment (see Chapter 8). Perhaps a more acceptable method would be to try to eliminate those instances of attention from others that accompany the boy's outbursts, and to make a serious attempt to give the boy attention when he is behaving appropriately. This approach is based upon research and theory that attempts to understand basic learning processes (Chapters 7 and 8) and their role in behavioral therapies (Chapter 22). It is an approach that utilizes answers from *what* and *how* questions in order to benefit an individual and those who interact with that individual.

Not all attempts by psychologists to help people solve their problems are successful, nor are they always developed systematically from basic theory and research. In fact, lack of success in treating many behavioral problems of adjustment reflects our ignorance about the basic mechanisms of behavior and about the causes of the particular disorder. In other words, we simply don't have enough data concerning the *what, how,* and *why* of behavior to be able to treat many disorders in a consistently effective fashion. This is why there is often more than one theory of, or therapy for, the *same* behavioral disorder. Of course, people suffering from emotional disorders, and those who interact with them by choice or necessity, do not have the luxury of waiting around until the incorrect theoretical alternatives have been identified and the basic puzzles of behavior are solved. For this reason, many different and sometimes contrasting therapeutic procedures have been devised by psychologists and other mental health professionals. Such procedures are designed to help people understand, manage, and possibly eliminate their behavioral problems (see Chapter 22).

The contributions of psychology to improving the quality of our lives are not restricted to the field of clinical psychology. Behavioral theory and research have played major roles in such diverse things as improving cockpit designs in commercial and military aircraft, using behavioral technology to control epileptic seizures in young children, and designing work environments that increase employee morale and productivity. We have included examples of several such specific applications throughout the text. Perhaps most relevant and satisfying, however, are those instances where you as a student can apply behavioral principles to your own life. This is a highly personalized and sometimes difficult endeavor. But we believe that nearly every student will find some aspect of the subject applicable and potentially beneficial.

A common example of applying principles of behavior for the betterment of humankind is that of a psychotherapist treating an emotionally troubled client.

Perspectives on Behavior

We believe that an introductory psychology text should describe psychology's endeavors accurately and as comprehensively as possible. We also believe it is useful to stress particular themes or perspectives, if doing so does not distort the true character of psychology. In fact, most introductory texts do emphasize certain themes or perspectives, but this is not always made clear to the student in the beginning.

The two perspectives we are stressing are development and evolution, topics already introduced in discussions of the *how* and *why* of behavior. There are two reasons for choosing these as vantage points from which to view behavior. First, psychologists and other behavioral scientists have become increasingly aware of the need to go beyond the immediate causes of behavior in attempting to understand it more fully. Consequently, during the past two decades there has been an upsurge in theory and research aimed at understanding developmental and evolutionary aspects of behavior. Second, developmental and evolutionary perspectives can be applied to many diverse topics in psychology. That is, we can at least ask about developmental and evolutionary influences on *any* behavior, although at this time we are a long way from having complete answers. Because of their wide range of possible application, these perspectives should provide continuity and thus make psychology more understandable and meaningful to you.

You should note that most of the material in the text is neither developmental nor evolutionary in nature. The concepts of development and evolution are used to provide important insights into behavior, and to help integrate many of the topics and ideas found in psychology.

2

The Nature of Psychology

Characterizing the Discipline of Psychology

Psychology's Past

The Emergence of Modern Psychology

Contemporary Developments in Psychology

Chapter Preview

This chapter describes the nature and focus of psychology as a scientific discipline, highlights the historical development of psychology, and discusses some of the trends that characterize modern-day psychology.

We begin by defining psychology as the scientific study of behavior. We then discuss major differences between psychology and other behavioral sciences—sociology, anthropology, and ethology. Psychology is unique because of its focus on individual behavior, and because of its extensive use of objective, experimental methods of investigation. Although psychology has a distinct identity, it nevertheless depends heavily on other disciplines, both scientific and nonscientific.

Psychology has both *basic* and *applied* aspects. Basic psychology is concerned with scientific research that investigates the *what, how,* and *why* of behavior. Applied psychology uses psychological theory and research to try to improve the quality of people's lives. There are several areas of specialization within both basic and applied psychology.

The remainder of the chapter examines historical roots and contemporary aspects of psychology. Our discussion of history begins with Aristotle, who was important to science for his emphasis on observation and reasoning as methods of gaining knowledge, and to psychology for his concern with a variety of behavioral phenomena. Unfortunately, Aristotle's empirical emphasis gradually disappeared following the Greek decline and the fall of Rome. The empirical approach resurfaced, however, in the sixteenth and seventeenth centuries to set the stage for the emergence of modern science.

Psychology was a latecomer compared to the physical and biological sciences, and was influenced heavily by them, particularly by physics and physiology. Psychology was established as a science in the late nineteenth century, but at the outset there was little unity regarding its goals. Rather, various schools of psychological thought began to emerge, and they differed mainly on their conceptions of what the subject matter and methodology of psychology should be. These major schools of thought were referred to as structuralism, functionalism, behaviorism, Gestalt psychology, and the psychoanalytic school. The first four of these shaped the content and methods of modern psychology, especially the behaviorist school, with its emphasis on objective behavioral research and on the study of conditioning and learning processes. The psychoanalytic school was important in influencing theory in the areas of personality, abnormal behavior, and development, and in providing a system of psychotherapy for clinical psychology and psychiatry.

Contemporary psychology is no longer dominated by these schools in a formal sense. Although psychology in the first half of the twentieth century was heavily influenced by behaviorism, the recent trend is a renewed emphasis on the psychology of thought processes—*cognition*—which early behaviorism ignored. Current conceptions of cognition are based on an information-processing model that attempts to explain thinking in terms of the operations of computers. Over the past two decades this approach has generated considerable knowledge about the nature of thought processes. Modern-day psychology is also concerned with *biological* bases of behavior, as is manifested by vigorous research activity investigating the neurophysiological aspects of behavior, and renewed interest in genetic and evolutionary influences on behavior. More than before, psychologists now are emphasizing the importance of understanding the *development* of behavior, from conception to death, as well as the *social* causes and consequences of behavior. Finally, psychology now shows more concern for understanding behavioral phenomena in *natural* as well as laboratory-experimental environments, a concern that did not characterize early psychology.

> The study of behavior encompasses all of the movements and sensations by which animals and [humans] mediate their relationships with their external environments—physical, [biological], and social. No scientific field is more complex, and none is more central to human problems and aspirations (Alexander, 1975, p. 77).

Characterizing the Discipline of Psychology

We stated in Chapter 1 that psychology studies behavior, including the capacities and dispositions that make behavior possible or likely to occur. But other disciplines also identify themselves as sciences of behavior. For example, *sociology, anthropology,* and *ethology* (a branch of zoology) can all be characterized as behavioral sciences. What, then, makes psychology unique, or at least justified in claiming a distinct identity as a scientific discipline?

First, psychology is concerned with the study of the behavior of individuals, whereas sociology and anthropology generally focus on the behavior of groups or systems. Second, psychology traditionally has emphasized human behavior as its subject matter, although not exclusively so, while ethology traditionally has focused on nonhuman behavior, but again not exclusively so. Finally, psychology has tended to use the **experimental method** in its observations of behavior, whereas the other disciplines mentioned have relied upon observational techniques that are less structured and controlled. The experiment is the most rigorous kind of observation used in science. It involves systematic manipulation of the **stimuli**—conditions or variables—that are thought to influence a phenomenon in order to gain a better understanding of that phenomenon.

Compared to sociology and anthropology, psychology tends to be a more experimental science because it is feasible to manipulate some of the variables that affect an individual's behavior, whereas this usually is not the case in investigations of social institutions and cultures. The greater experimental emphasis in psychology as compared to ethology appears to be a result of differences in tradition and objectives. Historically, psychologists have focused more on the *how* of behavior, particularly on the conditions in the external environment that influence behavior. The experimental method seemed to offer psychologists the most precise way of answering *how* questions about behavior. On the other hand, ethology arose from a tradition that emphasized the *what* and *why* of behavior, with special attention to the adaptive significance of behavior. This required an understanding of the organism's normal behavior within the context of its natural environment. Ethologists chose to acquire this understanding primarily by means of **naturalistic observation,** preferring to sacrifice the rigid controls of laboratory experimentation in order to lessen the risk of interfering with the behavior under scrutiny, or making it artificial. We will have more to say about ethology and the pros and cons of naturalistic observation and experimental methods later.

Although psychology has a distinct identity, it nevertheless overlaps with and depends upon several disciplines that have not been mentioned. For example, *physiology,* the biological study of bodily functions, forms the basis of an entire area of specialization within psychology—*physiological psychology.* Physiological psychologists investigate relations between nervous and endocrine systems and behavior. The field of *education* continues to be a fruitful source of psychological questions related to learning processes in general, and to the remediation and prevention of learning disorders in schoolchildren in particular. *Philosophy* forms the historical basis for psychology in terms of the questions, answers, and issues it has posed regarding human nature, the nature of behavioral phenomena, and the nature of scientific enquiry itself.

We have sampled only a few of the diverse disciplinary affiliations of psychology. You will no doubt recognize more of them, and come to appreciate the truly multidisciplinary flavor of psychology, as you read the sections and chapters that follow.

Areas of Psychology

Psychology, like several other sciences, has both basic and applied components. The term **basic psychology** refers to psychological theory and research related to the *what, how,* and *why* of behavior. Which centers in the brain control memory? What accounts for smiling in an infant, and how might the smiling response be adaptive? Which conditions in the environment facilitate or interfere with learning? To what extent are differences in intelligence due to inherited differences among individuals? Are chimpanzees capable of learning a human language? What makes people obey authority figures? Why are there sex differences in human aggression? How are stress and anxiety related to physical disorders? These are but a few of the diverse questions that have been or are now being investigated by psychologists doing basic research. These researchers typically hold the Ph.D. degree in psychology and are often affiliated with a university or research institute.

Applied psychology encompasses the activities of professional psychologists who attempt to improve the quality of people's lives. Applied psychology involves the application of basic theory and research (and often intuition and "gut feelings") to some of the problems individuals or groups must face in their day-to-day existence. A large number of psychologists are engaged in applied activities, and many of these activities are *clinical* in nature, meaning that they involve diagnosis and treatment of people in need of emotional support. However, there are areas of applied psychology other than clinical psychology. Among these are educational, industrial and organizational, and community psychology.

Table 2.1 is an outline of basic and applied psychology which lists and characterizes major areas of specialization. Please note that although it is relatively easy to break psychology down into separate parts on paper, it is sometimes quite difficult to place any one psychologist into a given slot. For example, one of your authors had a professor in graduate school who did basic research on learning processes, which falls under the category of general-experimental psychology. He also directed the developmental psychology graduate program, and did clinical work with retarded children at a nearby institution.

Psychology's Past

Contemporary trends and controversial issues in psychology are difficult to place in perspective without some knowledge of the discipline's history. Many times the reasons for psychology's preoccupation with a particular point of view can be understood only in terms of significant events and people that preceded the emergence of psychology as a scientific discipline. In this section we review some of the major historical influences on the scientific study of behavior in general, and psychology in particular. Our purpose here is simply to present a brief and general account of some of these influences, rather than a lengthy historical treatise. Entire texts have been devoted to describing only portions of the material we summarize in the next few pages, and you will need to consult such works if you want a deep understanding of, and genuine appreciation for, the richness of psychology's past (see Watson, 1978).

TABLE 2.1 Areas of Psychology

Basic Psychology	
Area of Specialization	*Focus*
Biological Psychology	Physiological bases of behavior
	Neuropsychology (brain and behavior)
	Comparative psychology (species differences and similarities in behavior; adaptive significance of behavior)
	Behavioral genetics (inheritance of behavior)
Developmental Psychology	Developmental psychobiology (biological bases of development)
	Ethological and comparative development (species differences and similarities in development; adaptive significance of behavioral development)
	Learning and development
	Cognitive development
	Personal-social development
General-Experimental Psychology	Learning processes
	Motivation
	Cognitive processes (sensation, perception, memory, thinking, language)
Quantitative Psychology	Research design and statistical analysis
	Tests and measurements
	Mathematical models of behavior
	Computer simulations of intelligence
Social Psychology	Person perception
	Attitude formation and change
	Social motivation
	Socialization
	Communication
	Aggression and altruism
Psychology of Personality	Organization of personality
	Emotion
	Stress and anxiety
	Individual differences
	Abnormal behavior

Pre-Nineteenth-Century Influences

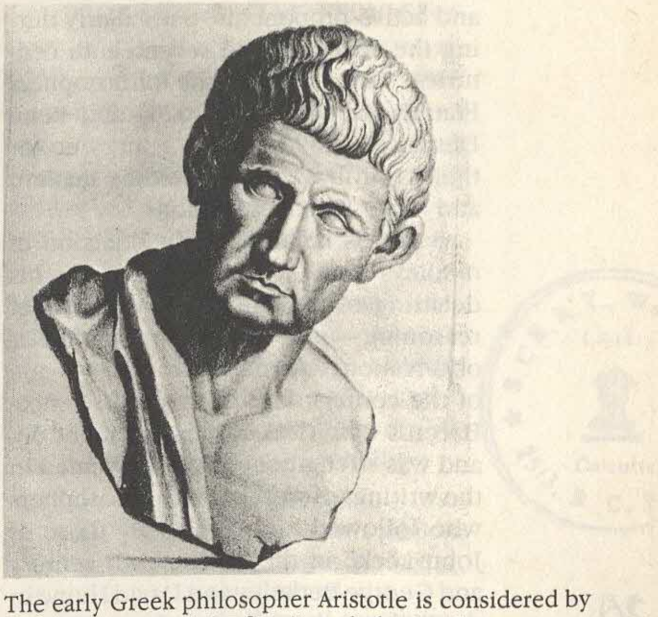
Although psychology did not emerge as a scientific discipline separate from philosophy until the late nineteenth century, interest in studying psychological phenomena can be traced as far back as the early Greeks. Aristotle (384–322 B.C.) was the first Greek philosopher to propose a systematic study of living organisms, and he included the individual "psyche" (soul or mind) as a central focus in this study. He wrote prolifically about topics that constitute the subject matter of modern psychology—sensation, perception, motivation, learning, memory, thinking, emotion, and development. Perhaps Aristotle's most important contributions were some of his assumptions about human nature, behavior, and how behavior should be studied. Unlike his teacher Plato, Aristotle did not accept mind-body dualism, the notion that mind and body are separate entities. In fact, he believed that the "psyche," as one aspect of life, was governed according to lawful relationships just like other natural phenomena. Therefore, Aristotle placed a great premium on systematic observation and

TABLE 2.1 (continued)

Applied Psychology	
Area of Specialization	*Activities*
Clinical Psychology	Psychological testing Diagnosis of psychological disorders Individual and group therapy
Counseling Psychology	Psychological testing Diagnosis of normal problems of adjustment Individual and group counseling
School Psychology	Psychological testing Diagnosis of psychological and educational problems Individual and group counseling (All of these activities take place in elementary and secondary school settings)
Psychometrics	Psychological testing Application of principles of measurement
Educational Psychology	Research and application of principles of learning and cognition in educational settings Design and evaluation of curricula according to psychological principles
Industrial and Organizational Psychology	Research and application of psychological principles in work settings Psychological testing and screening of personnel
Engineering Psychology	Research investigating the relationship between people and machines Design and modification of machines and machine use according to psychological principles
Community Psychology	Research investigating effects of the environmental structure of communities on behavior Design and modification of community structure according to psychological principles

logical inference as necessary methodological steps toward understanding the complexities of behavior. Of the early Greek philosophers, Aristotle perhaps made the most significant contributions to the establishment of psychology as a science.

Unfortunately, the scientific impact of Aristotle's writings began to disappear after the Greek decline, and his works essentially were lost to the Western world for several centuries after the fall of Rome in 476 A.D. For a variety of reasons, the Middle Ages were characterized by a nonscientific, and in many cases antiscientific, attitude. These times, which marked the rise of the major religions, were not ripe for the emergence of a science of behavior or, for that matter, a science of anything. Truth was



The early Greek philosopher Aristotle is considered by some to be one of the first "psychologists."

sought through consultation with authority, such as the writings of the church fathers, not through observation and reasoning, unless the latter yielded results in agreement with existing religious dogma.

When Aristotle's works were rediscovered in Christian Europe during the thirteenth century, they had an immediate impact on religious thinkers. Aristotle's systematic methods of reasoning were seized upon to help justify and buttress articles of religious faith. There were other aspects of Aristotle's writings, however, that posed problems for the champions of religious authoritarianism, particularly his emphasis on an **empirical** approach in which knowledge derived from direct observation rather than from theory or faith. Thus Aristotle, so helpful to religion in some ways, nevertheless advocated an approach to knowledge that many of the church fathers considered useless or subversive.

The empirical approach to knowledge attracted increasing numbers of admirers and active proponents, particularly during the sixteenth and seventeenth centuries. Among these the philosophers Francis Bacon (1561–1626) and René Descartes (1596–1650) stand out for their contributions to scientific method and its possible applications.

Bacon is famous for his rejection of medieval authoritarianism, and for his detailing of the **inductive method** of reasoning — proceeding from particular observations to general principles — one of the cornerstones of modern science. Bacon's empirical emphasis caught on, and was strengthened and elaborated in the writings of well-known philosophers who followed him, especially those of John Locke in the seventeenth century and George Berkeley and David Hume in the eighteenth.

Descartes, on the other hand, emphasized **deductive method** — proceeding from general principles to particulars — and paved the way for the sciences of anatomy, physiology, and psychology by proposing that both physical and psychological functioning in nonhumans could be explained by fundamental physical and chemical principles.

Contemporaries of Bacon and Descartes who were instrumental in the emergence of modern science included the astronomer Galileo Galilei (1564–1642) and the physician William Harvey (1578–1657). Galileo amassed a great deal of evidence to support the then controversial Copernican notion that the sun rather than the earth was the center of the

René Descartes, a Renaissance philosopher, contributed greatly to the scientific method and paved the way for mechanistic explanations of behavior.

universe. The religious hierarchy was not impressed with his arguments or his facts, however; he was forbidden to propagate such "heresy" and was eventually imprisoned. Galileo also laid the foundation for the science of physics by demonstrating that physical phenomena could be understood in terms of principles of motion, principles that Isaac Newton (1642–1727) later elaborated and quantified. Harvey published an important essay describing for the first time the circulation of blood, a crucial step in the development of physiology, which in turn later played an important role in the emergence of scientific psychology.

The intellectual revolt of the seventeenth century resulted in a severe questioning of existing authority and the rise of an empirical, scientific approach to knowledge. Some historians suggest that this revolution not only created modern science, but also influenced many of the changes that were taking place in literature, architecture, politics, and religion (Willey, 1951). At the very least, the intellectual movement of the seventeenth century accelerated the acquisition of knowledge and technology beyond all previous comprehension. Science as we know it today had gained a foothold, and it was only a matter of time before the domain of science would be extended beyond physical phenomena to biological and psychological phenomena.

The Emergence of Modern Psychology

Psychology was a late arrival compared to the physical and biological sciences, although there had never been a lack of speculative interest in psychological matters. Basic psychology first emerged as a scientific discipline in the late nineteenth century, and was heavily influenced by the fast-maturing biological sciences and by physics. In particular, **psychophysics,** the systematic attempt to relate sensory experience (for example, the sensation of brightness) mathematically to physical aspects of external stimuli (in this example, illumination), was instrumental in shaping the theoretical interests and research methodologies of psychology. In addition, neurophysiological studies during the nineteenth century were contributing important knowledge about sensory and motor capacities and the relationship between behavior and certain areas of the brain. The first individuals to construct a science of psychology were, for the most part, identified with one or both of these disciplines, and so it is not surprising that early psychology had a distinctly psychophysical and physiological flavor.

Biology also exerted an influence on psychology, in the form of Charles Darwin's theory of evolution. Darwin's emphasis on adaptation, and on the connection between individual differences and biological inheritance, affected the thinking and activities of many of the early psychologists. They began to focus on understanding the adaptive properties of behavior, the development of behavior, and differences in behavior among individuals and across species. Because of Darwin's influence many biologists also became interested in behavior, especially nonhuman behavior as it occurs in the animal's natural environment. Howard Gruber, a psychologist, sums up nicely the important contributions made by Darwin to psychology:

> [Darwin's] materialist approach to biology helped lay the basis for a modern view of the brain as the organ in which mental functions are centered. His insistence on the intellectual continuity

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> of man and other animals speeded the rise of comparative psychology and the study of animal behavior. His study of the emotional continuity of man and other animals provided Freud with a valuable springboard for the development of psychoanalysis. His concern for the adaptive significance of all biological functions helped in the construction of a functional psychology focussed on the interplay and utility of psychological processes, as compared with a structural psychology preoccupied with the discovery of the static elements of experience. His interest in variation led quite directly to an upsurge of interest in individual differences in psychological functioning as compared with the search for the laws of a generalized mind. The synthesis of embryology and evolution provided a point of view for the emerging field of child psychology (Gruber & Barrett, 1974, pp. 218–19).

A movement to understand and treat abnormal behavior scientifically was underway by the early 1900s, given impetus mainly by biology and medicine. The rejection of demonism and witchcraft as explanations for abnormal behavior brought about a more humane approach to those with mental disorders, and served as a stimulus for finding the causes of these disorders. The discovery that certain forms of intellectual and emotional deterioration—specifically the paralytic condition known as general paresis—were due to brain damage suggested that other mental disorders might also have underlying physical causes in the nervous system, and produced a great deal of optimism for an eventual scientific understanding of abnormal behavior. Finally, the observation that persons afflicted with certain psychological disorders could be treated successfully using hypnosis and other nonbiological procedures laid groundwork for the eventual dawning of clinical psychology, and heavily influenced the related medical discipline of **psychiatry.***

In the beginning there was little unity concerning the goals psychology should pursue. Rather, individuals began to form groups representing various schools of thought in psychology. **Structuralism, functionalism, behaviorism, Gestalt psychology,** and the **psychoanalytic school** represented the major philosophies of early psychology. The differences among these schools were due mainly to differing opinions as to what should constitute the proper subject and methodology of psychology. These technical disagreements, however, often revealed more basic philosophical differences regarding the nature of science and human nature itself.

Structuralism

The beginning of psychology as a science usually is traced to the establishment of a psychological laboratory in Leipzig, Germany, in 1879 by Wilhelm Wundt.† Wundt was a professor of physiology who became interested in mapping the *structure* of human conscious experience. He and his students insisted that psychology should be concerned with the analysis of conscious experience into its constituent elements. The goal of the structuralists was to construct

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* Psychiatry is the area of *medicine* specializing in the understanding and treatment of psychological disorders. Psychiatrists hold the M.D. degree, while clinical psychologists hold the Ph.D. in psychology. Despite differences in training, there is much overlap between the activities of psychiatrists and clinical psychologists.

† Actually, there is some dispute over this date. Watson (1978) argues that 1875 is a more accurate estimate. He also indicates that William James may have had a psychology laboratory in operation by this time in the United States.

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mathematical laws that would relate perceptual experience, emotion, and other aspects of consciousness to more specific or basic components, such as sensations and feelings. Wundt used the experimental methods of the psychophysicists and physiologists, coupled with a very systematic version of introspection, in which subjects reported on their inner mental and emotional states under various experimental conditions. Essentially, then, the school of structuralism was characterized by (1) an emphasis on *conscious* experience as the appropriate subject matter of psychology; (2) a focus on the *elements* or building blocks of consciousness; and (3) a heavy reliance on the method of *introspection*.

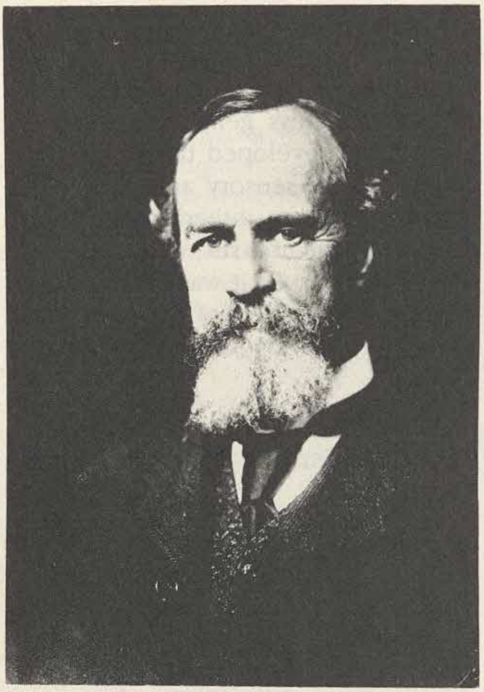
Wilhelm Wundt established the first laboratory of psychology in the nineteenth century in Germany and led the school of structuralism in psychology.

Although the structuralists fell short of realizing Wundt's dream of establishing precise laws of conscious experience, they nevertheless generated much research, and developed the experimental analysis of sensory and perceptual phenomena as an integral part of psychology. Structuralism was especially significant because it was the first comprehensive statement of what goals and methods psychology as a science should adopt.

Functionalism

At about the same time that Wundt and his students were attempting to uncover the structural aspects of conscious experience, others concerned with psychological matters were suggesting a different emphasis. William James, a physician by training, made a distinction between the structure and the function of conscious experience. James believed the mind should be viewed as a system of processes, or *functions,* rather than as a set of structural components. Moreover, he stressed that mental activity functioned to adapt the individual to the environment, a point echoing Darwin's emphasis on the adaptation of physical and behavioral characteristics in evolution.

When these ideas were elaborated and expanded in the 1890s and early 1900s by John Dewey and James Angell at the University of Chicago, the functionalist school came into being. Like the structuralists, the functionalists regarded human conscious experience as an appropriate focus for psychology. Their approach also involved a certain degree of mental analysis, and they used both experimental and introspective methods. Unlike the structuralists, however, they emphasized mental *activities* rather than



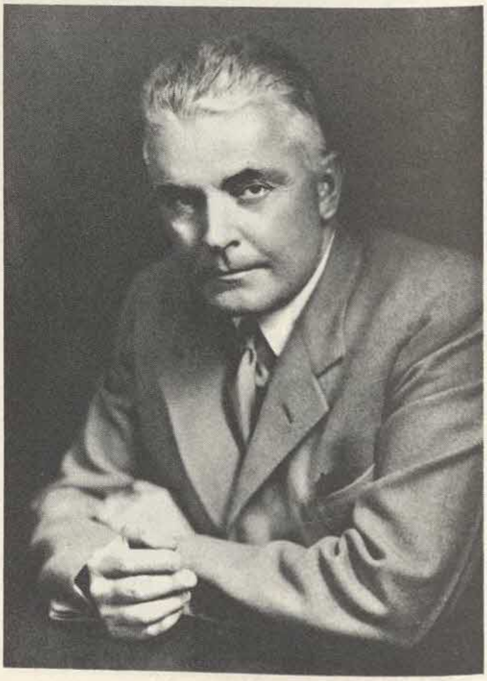
William James, a famous nineteenth- and twentieth-century American philosopher and psychologist, established the first psychology laboratory in the United States. His ideas formed a basis for the school of functionalism in psychology.

structures, and the *adaptive value* of those activities. In addition, they extended psychology's focus to include all overt behavior, nonhuman as well as human. Learning processes, because of their important role in adapting the individual to the environment, became a central topic of study for the functional psychologists. They made contributions to the understanding of individual differences in intelligence and personality, and enriched applied psychology, especially educational psychology. Functional psychology, broader in scope than structuralism, served to open up new and exciting areas for psychological research and application.

Behaviorism

Thirty-four years after Wundt had established his psychological laboratory in Germany, an American psychologist, John B. Watson, planted the seeds for what was to become a full-scale revolution in psychology. In a publication entitled "Psychology as a Behaviorist Views It," Watson lashed out at the existing theoretical approaches and methodologies of the fledgling science. In particular, Watson attacked the structuralist school's focus on conscious experience and its heavy reliance on the method of introspection, arguing that if psychology was to become a truly objective science it could not afford to tolerate either of these preoccupations. Objective sciences such as physics dealt with *observable* phenomena, and used research

John B. Watson was the founder of the school of behaviorism in American psychology.



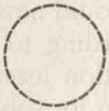
methods that minimized subjective bias. Conscious experience is a "hidden" phenomenon, not directly observable, and therefore could never be measured precisely, according to Watson. Moreover, introspection leaves a substantial amount of room for subjective bias and error. Indeed, the method as employed by the structuralists was turning up many discrepancies and few, if any, generalized laws of conscious experience.

Watson's thinking was influenced by the writings of Ivan Pavlov, a Russian physiologist who won the Nobel Prize for his studies of digestive processes, but who achieved his greatest fame for illuminating the mechanisms responsible for the conditioning of reflexes. While a **reflex** is an unlearned, automatic response to a specific stimulus such as an eye blink in response to a puff of air, a **conditioned reflex** is a learned response. Pavlov had shown that animals learn to respond reflexively to stimuli other than those which are normally effective. For example, a dog could be conditioned to salivate at the sound of a metronome when the sound was repeatedly paired with the normally effective stimulus, the placing of meat powder on the dog's tongue. Impressed with Pavlov's success, Watson proposed that the **stimulus-response (S-R)** concept of the reflex be used to understand behavior—that is, that behavioral responses should be analyzed according to the external, environmental stimuli that elicited them. Watson believed that all behavior, even very complex behaviors such as language and emotion, could be reduced to S-R connections or associations. Watson also assumed that many of these associations were acquired and elaborated through conditioning processes such as those demonstrated by Pavlov.

The behavioristic proposal had an immediate impact on psychologists, and by the 1930s behaviorism was the dominant influence in scientific psychology, particularly in the United States (Watson's version) and the Soviet Union (Pavlov's version). Introspection was no longer accepted by most psychologists as scientific, or as a method that could stand alone. Conscious experience and other "mentalistic" phenomena were out; S-R psychology (sometimes referred to as "knee-jerk psychology" by critics of behaviorism) was in. The behavioristic revolution had succeeded quickly, and that its influence was so widespread and long lasting was due in no small measure to the influence of B. F. Skinner, who followed Watson and became the leading proponent of behaviorism in the twentieth century. Skinner is best known in psychology for his research and theory related to the conditioning of operant behavior, behavior that is under a greater degree of voluntary control than are reflexes. Skinner coined the term **operant conditioning** to refer to principles of behavioral change—learning—based on the application and withdrawal of rewards and punishments. Skinner demonstrated quite convincingly that animal behavior can be modified rapidly and effectively through the systematic use of reward and punishment. Although most of his research used pigeons and rats as subjects, Skinner theorized that his principles of conditioning characterized much of the learning that goes on in a wide variety of species, including humans. He is perhaps best known to the general public for *Walden Two* (1948), a utopian novel, and *Beyond Freedom and Dignity* (1971), a psychological treatise, both of which outline a behaviorist's solutions to societal and world problems. There is no question that the behavioristic approach made psychological researchers more careful, critical, and sophisticated in their methods. Too, the behavioristic emphasis on conditioning and learning led to enormous amounts of research and some highly systematic theorizing concerned with basic learning mechanisms and their application in the clinic and the classroom.

Gestalt Psychology

The seeds for yet another psychological school were being sown in Germany by Max Wertheimer about the same time Watson was launching behaviorism in the United States. The German word *Gestalt* means, roughly, configuration or form. Wertheimer thought that psychology should concern itself with dynamic configurations *(Gestalten)* of conscious experience and behavior, rather than with static elements (sensations, feelings, S-R units). To illustrate this point, consider your perception of this visual stimulus:



Usually it is perceived immediately as a circle, not as an unfamiliar figure or as a series of lines or spaces, even though it is not a *completed* circle. But in order for this to happen, the perception must be influenced by more than the individual visual sensations corresponding to each line and its orientation. Perhaps the brain integrates these sensations into a unified Gestalt—a circle. Based upon this and many other similar examples, Wertheimer reasoned that dynamic organization was inherent in the act of perceiving. This view was quite different from Wundt's notion that perceptual experiences could be accounted for simply in terms of a composite of discrete, elemental sensations. In essence, Wertheimer proposed that conscious experience and behavior were more than the mere sum of their constituent elements. Wertheimer's notions generated a number of studies on perception that often turned out to support his views. The methods used included unstructured forms of introspection—**phenomenological investigation**—as well as more rigorous experimental procedures.

Max Wertheimer was one of the founders of the Gestalt school of psychology.

Wertheimer came to the United States in 1933 and settled at the New School for Social Research in New York. Two other leaders of the Gestalt school of thought, Kurt Koffka and Wolfgang Köhler, also emigrated from Nazi Germany to the United States at about the same time. Under their leadership, Gestalt psychology, which had started out as an attack on the elemental approach of structuralism, soon extended its attacks to behaviorism.

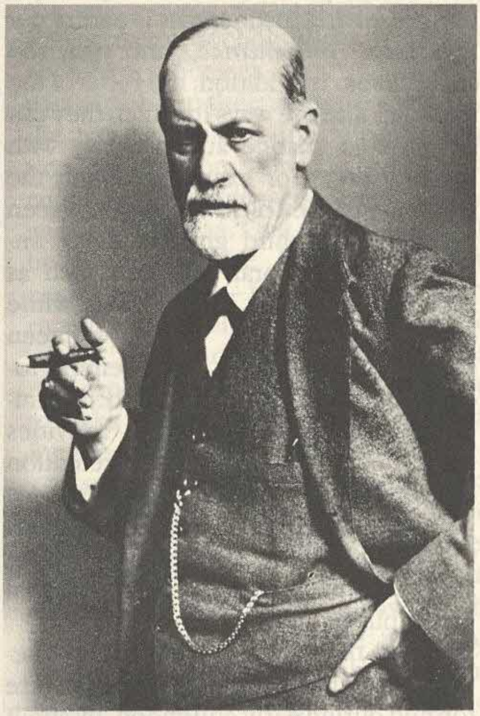
The Gestalt psychologists criticized the behaviorists for reducing behavior to S-R elements, arguing that this approach ignored individual needs and interests that can interact with perceived stimuli to influence behavior. Moreover, the designation *S-R* implies that an environmental stimulus *directly* affects a response. The Gestalt psychologists pointed out that it is a person's *interpretation* or representation of the external environment, not the environment itself, that influences behavior.

Gestalt psychology had its greatest impact in the area of perception, but like structuralism it never really influenced other areas of psychology in a significant way. This relative lack of acceptance may have been related to the rather firm foothold the behaviorists enjoyed at the very time Gestalt psychology was attempting to get off the ground in the United States.

The Psychoanalytic School

The term *psychoanalytic* refers to a theory of personality as well as to a therapeutic procedure used to treat emotional disorders. Psychoanalytic theory and the therapy based upon it—**psychoanalysis**—were the creations of Sigmund Freud, a Viennese physician who had specialized in neurology. The psychoanalytic school emerged in the late nineteenth century, but its heyday was during the first forty years of the twentieth. Unlike the other four schools we have discussed, the psychoanalytic school developed in applied clinical settings rather than within the confines of the university.

Freud's theory focused on human motivation, more specifically **unconscious** sexual motivation. Freud theorized that much of human behavior is governed by powerful motives that are, for the most part, hidden from conscious awareness. Although others had talked about the unconscious long before Freud (Plato, for example), the fact is that Freud was the first to make it the central theme of a systematic theory of personality. Essentially, Freud believed that behavior is driven by attempts to satisfy pleasure-seeking (sexual) impulses that operate at the unconscious level of personality. Furthermore, parts of the personality seek to inhibit or otherwise control the expression of these impulses. Behavior is determined by the dynamic interplay of these pleasure-seeking impulses and inhibitory processes. At the same time, the nature of the interplay is affected by biological, developmental, and experiential factors. According to Freud, sexual impulses arise from a generalized



Sigmund Freud is considered the "father" of psychoanalysis.

life-preserving instinct that is part of our *biological inheritance,* and that he called **Eros.** In addition, the focus of the impulses and the ways in which they can be gratified change automatically with *development.* For example, during the first stage of life (birth through eighteen months), the child gratifies these impulses through oral activities such as sucking, mouthing, and biting, while during the second stage (eighteen months to three years), sexual energy focuses on the anal region, and the impulses are gratified through activities associated with elimination or retention of feces. Finally, an individual's *experience* is important because it determines the strength of the impulses as well as the strength of the forces that seek to control the impulses.

Freud theorized that the basic structures and functions of personality were formed during early childhood, by about the sixth year of life. He also believed that emotional disturbance—**psychopathology**—resulted from disruption of the dynamic balance of forces that determine behavior. That is, an individual may become disturbed when unconscious sexual impulses become too strong, when factors inhibiting those impulses become too strong, or when anxiety due to the impulse-inhibition conflict cannot be reduced in an adaptive way.

Freud supported his theory with data obtained from clinical interviews with patients. The methods he used often depended upon having patients recall childhood events. Many of the more academically inclined psychologists, especially the behaviorists, considered Freud's methodology subjective and scientifically inadequate. Nevertheless, Freudian psychoanalytic theory had an important impact on psychology, especially during the first half of the twentieth century. In particular, Freud's emphasis on unconscious psychological processes gave direction to psychologists' efforts to understand personality, and to treat abnormal behavior. In addition, Freud's assertion that early childhood is a critical time for personality development played a major role in the emergence of child development as an area of specialization within psychology. Perhaps most important, the doctrines of the psychoanalytic school, including those of Freud's colleagues Alfred Adler and Carl Jung, had profound effects on disciplines other than psychology, and brought about a change in the way most people think about their own behavior and the behavior of others.

Contemporary Developments in Psychology

The schools of psychology we have discussed no longer exist in their original forms. Nevertheless, their influence in determining the goals, content, and methods of both basic and applied psychology cannot be overemphasized. Structuralism and Gestalt psychology had their greatest impact in the areas of sensory processes and perception, functionalism and behaviorism shaped the psychology of learning processes, and the psychoanalytic school helped establish the scientific study of personality and abnormal behavior and gave direction to clinical psychology.

Although each school left its unique imprint on psychology, behaviorism probably has had the most widespread influence, particularly in basic psychological theory and research. It was responsible for psychology's preoccupation with overt behavior rather than thought and conscious experience until the early 1960s in the United States, Canada, and several other countries. In fact, the behavioristic notions of Pavlov continue to serve as a foundation for most psychological research carried on in the Soviet Union today. Behaviorism also emphasized rigorous experimental laboratory research methods, and questioned the value of nonexperimental methods. Finally, the behaviorists emphasized conditioning and learning as the basic environmental determinants of behavior, unfortunately to the exclusion of other environmental factors as well as genetic factors.

Contemporary psychology still reflects the behavioristic influence, especially the emphasis on objective research methodology. However, in the past twenty years or so psychology has incorporated views of behavior that differ in many ways from a strict behavioristic S-R analysis, and from the other views we have discussed.

The Mind Revisited: Information Processing

Psychology in the last two decades has returned to a focus on thought processes and even conscious experience (Ornstein, 1977). In fact, many of the more recent modifications in traditional behavioristic learning theories have made **cognition**—the process of knowing—a central theme. This has been the case even for theories that attempt to explain learning in rats, pigeons, and other nonhuman species (Rescorla & Wagner, 1972). There is a marked difference, however, between the approach of present-day psychologists and that of some of psychology's founding fathers. Introspection is no longer relied upon as the major source of data about cognition. Rather, many psychologists investigating cognitive processes carry out rigorous experiments in their attempts to explore the largely uncharted terrain of cognition. In addition, new explanations of cognition have replaced the structuralist and Gestalt ideas. One such explanation in particular—the **information-processing model**—has generated much research and insight into cognitive processes. Before describing the information-processing model, it may be useful to make a few general remarks concerning the nature of scientific models.

A scientific **model** is an attempt to explain something unknown in terms of principles that are already well understood. For example, Pavlov's model attempted to understand behavior (the unknown) in terms of the functional properties of reflexes (the known). Models are always subject to change or abandonment, depending upon the status of knowledge within a discipline and upon new technological developments that can provide more suitable models. For example, early scientists once thought that the heart (the unknown) worked like a furnace (the known) in regulating body temperature. Later, following the discovery of principles involving pressure, compression, and circulation, the development of pumps based on these principles, and the dissection of bodies to allow direct examination of the heart, the furnace model of the heart was abandoned in favor of a more accurate pump model.

In contemporary psychology, the information-processing model (Figure 2.1) attempts to explain cognition (the unknown) in terms of the operation of computers (the known). The advent of computers in the late 1950s gave psychologists a way of characterizing think-

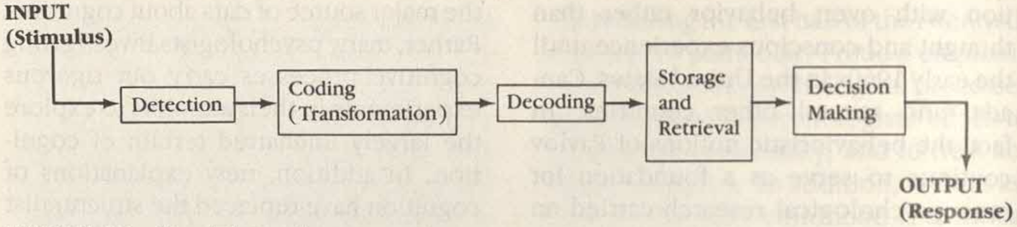


FIGURE 2.1 The information-processing model.

ing processes. Computers detect and analyze information, store it for future use, search for, locate, and retrieve information, and make decisions and solve problems based upon the information they have stored. Of course, they must be told how and when to do all these things (they must be *programmed*), and that is the fundamental difference between machines that process information and organisms that do so. In fact, organisms equipped with a central nervous system — brain and spinal cord — are infinitely more flexible information processors than even the most sophisticated computer. This is particularly evident in the case of humans, who have evolved the most complex and adaptable information-processing system in existence.

Despite these important differences between computers and living beings, there are some basic similarities. Even very simple one-celled organisms somehow detect and analyze information. That is, they sense certain changes in their immediate surroundings — those changes which are important for them to detect in order to survive and generate more one-celled organisms. In addition to *detecting and analyzing* information, many organisms are capable of learning; they are genetically programmed for *storing and retrieving* information. And, of course, deliberate and sophisticated *decision-making* is the hallmark of human information processing, although we as well as other animals also "make decisions" that are automatic or reflexive, and that sometimes are not very sophisticated.

Thus the information-processing model of cognition provides us with an enriched view of behavior compared to earlier behavioristic S-R models, and a more objective approach to understanding the mind than those of the structuralists or Gestalt psychologists. More important, the information-processing model has generated considerable research and many new insights into the nature of thought processes. For example, we now know a great deal more about the essence of **memory.** Memory is the core component of human information processing, and there is good evidence to suggest that it does not function simply as a sort of passive repository for information. Rather, memory is best characterized as a dynamic system of storage and retrieval strategies that play important roles in other aspects of information processing — detection and analysis, decision-making, problem-solving. We will have more to say about memory in Chapter 13, and about other cognitive activities in the chapters in Unit V. For now, simply note that the information-processing model's popularity is based not only upon its appeal as an apparently good way of conceptualizing cognition, but also upon the fact that it has led to important discoveries about the structure and function of cognition.

Exploring the Biological Frontiers of Behavior

As we saw earlier in the chapter, in the nineteenth and early twentieth centuries the emerging science of psychology was heavily influenced by biologists, particularly the neurophysiologists, and of course by Darwin. The neurophysiological basis of behavior has been an area of interest within psychology throughout its history, particularly since the late 1950s. Physiological psychologists, neurophysiologists, and other neuroscientists have discovered a great deal about nervous system functioning and about the ways in which this functioning can affect behavior. In fact, there has been a virtual explosion of knowledge in this area during the past ten to fifteen years. We now know, for example, that specific nerve pathways that lead to various sites in the brain are involved in our conscious experiencing of pain. Recent discoveries have also shown that relief from pain is associated with opiate-like substances produced naturally by the brain acting upon special nerve endings in the pain centers (Snyder, 1977). This research may be extremely important in developing more effective and less addictive substances for the control of chronic pain associated with various diseases, psychological disorders, and injuries.

Many other important findings have emerged recently from the laboratories of physiological psychologists, including a new and ever-increasing understanding of sleep and other rhythmic patterns of bodily activity; a realization that the two halves (hemispheres) of the brain sometimes function as though they were two separate brains in determining behavior; and a better understanding of the role of hormones in influencing the transmission of nervous impulses, the development of sex-related behaviors, aggression, and various reactions to stress. We discuss these and other topics related to physiological psychology in more detail in Chapter 9. Suffice it to say here that recent investigations of the relationship between physiological functioning and behavior have made giant strides toward providing a more complete understanding of behavior, and that the results of these studies have important implications for applied psychology, psychiatry, and the practice of medicine.

Another biological emphasis in modern-day psychology involves a renewed interest in and appreciation of genetic influences on behavior. In the past, psychology has been preoccupied with environmentalist explanations of behavior. Such explanations, which were particularly in vogue during the heyday of behaviorism, often implied that the most important determiner of behavior is the external environment. Genetic influences on behavior were considered weak or absent, and in any case unimportant. And many psychologists considered human behavior in particular to be infinitely modifiable, stating or at least implying that most people can learn to do almost anything, regardless of inherited capacities or dispositions. Of course, many proponents of the opposite point of view, that heredity is the most important force in structuring behavior, were just as one-sided and extreme as the radical environmentalists.* Today, however, the heredity-environment issue is no longer cast in such an extreme, either-or form. Thanks to increasing knowledge and the gradual elimination of bias, we have come to understand that heredity and environment are *both* important in influencing behavior—that both are essential for the existence of any behaving organism. This change in attitude has made possible a new effort by many psychologists and biologists to understand the role of genetic factors in influencing behavior, including individual differences in behavior in various environments. This area of investigation is called behavioral genetics, a topic we address in greater detail in Chapter 5.

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* You may recognize that the heredity-versus-environment issue is not a product of psychology. In its more general form it is called the **nature-nuture** issue (nature being heredity, nurture the environment), and it has been debated at least since the time of the early Greeks, circa 300 B.C.

Related to contemporary psychology's renewed interest in genetic influences is an upsurge of curiosity about the evolutionary roots of behavior. This is quite logical, since our genetic programming and that of other animals is a product of natural selection. The genes that influenced our prehuman and human ancestors' physical structures and behaviors in ways that contributed to their survival hundreds of thousands or even millions of years ago have been preserved by natural selection. Thus a more complete understanding of genetic influence on behavior requires some knowledge of our ancestors and the environmental challenges they faced (see Chapter 4). An evolutionary analysis of behavior may help predict which kinds of capacities, dispositions, and behaviors might be under stronger genetic influence than others.

Behavior as a Developmental Phenomenon

More and more, psychologists are finding that a developmental analysis can provide a more complete understanding of behavior. The value of a developmental perspective has long been recognized by clinical psychologists, psychiatrists, and other mental health professionals. Understanding the personality dynamics of a troubled person is more than a matter of observing current behavior. A *case history* describing the person's past is prerequisite to rendering an accurate clinical diagnosis and deciding on a program of treatment. Throughout his career Freud emphasized the importance of a developmental analysis of behavior, and an emphasis on development has continued to characterize most clinical psychological activities throughout the twentieth century. It is only recently, however, that a consideration of development has become more prominent in areas of basic psychology. There is now a good deal of interest in learning more about how basic genetic and environmental factors interact to account for the development of various behaviors and behavioral capacities. For example, it appears that some individual differences in temperament, such as emotionality and level of sensitivity to stress, may be due in part to genetic or prenatal environmental influences.

In the area of human social behavior, there is evidence to indicate that our ability to form friendships and affectional bonds with others is related to the kinds of interactions we carried on with our parents as infants. In the area of human cognition, Jean Piaget, the famous Swiss psychologist, biologist, and philosopher, did more than anyone else to call attention to the importance of development. Piaget, active until his death in 1980, is clearly the most influential developmental psychologist of all time, and undoubtedly will be remembered as one of the major influences on all of psychological thought during the twentieth century. Piaget's theory and research has taught psychologists investigating cogni-

Jean Piaget, trained as a biologist, formulated the most influential theory of cognitive development to date.

tion two important lessons. First, adult thinking can best be characterized as a natural modification and reorganization of previous forms of thought from infancy on. Second, research on adult thinking can never tell us about thinking in general. Children are not simply miniature adult thinkers; their thought may be substantially different from that of adults, and therefore it deserves attention as a phenomenon in its own right.

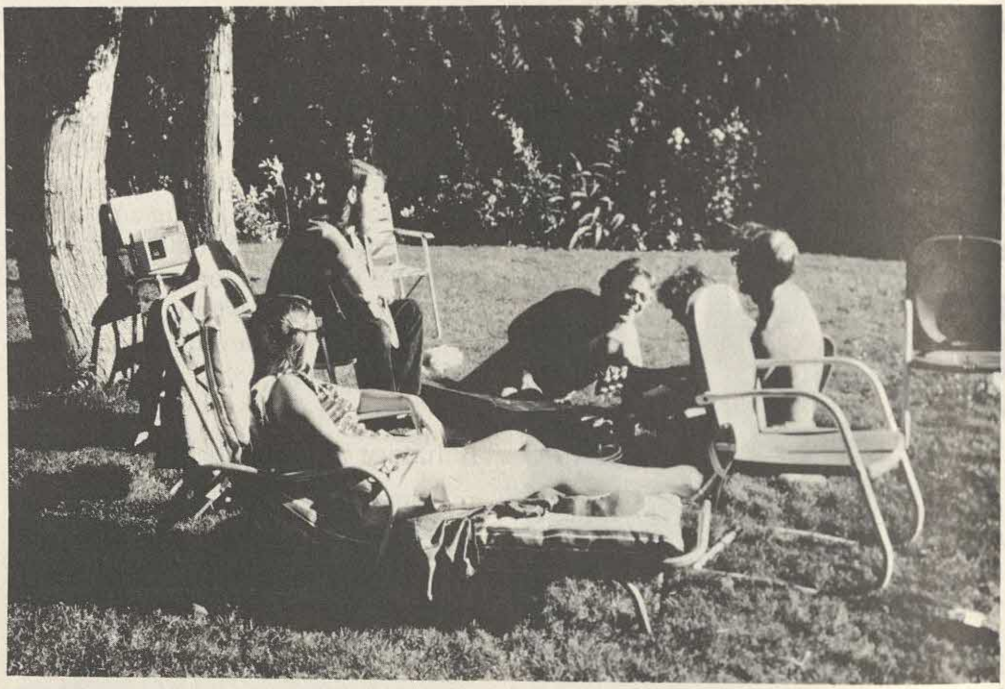
Although our examples of developmental considerations have emphasized early developmental influences, one of the major trends within developmental psychology over the past ten years has involved focusing on other parts of the developmental spectrum. Development does not cease with the attainment of sexual maturity, and adult organisms of any species continue to be subject to changing physiological and external environmental conditions that can affect behavior. More than ever before, psychologists and other social scientists are beginning to mount a serious effort to understand the specific needs and problems associated with young and middle adulthood and the retirement years. It is clear that we can no longer hope to understand behavior without taking into consideration the developmental status of the organism.

Behavior as a Social Phenomenon

It is difficult to imagine any behaving organism existing for very long in a world where there were no other behaving organisms. To be sure, there are dramatic species differences in social needs and organization. Humans, other primates, whales and porpoises, wolves, and several species of insects seem to be among the most social of all animals. However, in a broad sense all animals are social to some extent, and their behaviors usually have social antecedents or social consequences.

Human behavior occurs and develops within a social context from the moment of birth until the cessation of life. Developmental psychologists have become increasingly aware that an infant's simple reflexive responses such as smiling, crying, grasping, and babbling have enormous social consequences. Such behaviors can (and do) elicit attention and caretaking activities from parents. In turn, the parent's smiles, words, touches, and hugs stimulate and reinforce the infant's behaviors. Thus humans do not have to learn to be social; we are beginning to see very clearly that human behavior is social from day one.

Increasing concern over violence, overcrowding of cities, poverty, preju-



The instance of behavior in the photo is easily identified as social in nature. However, it is difficult to imagine any human behavior that does not have social implications.

dice, and pollution; demands for reduced energy consumption; and general concern over the quality of life have made understanding the social causes and consequences of behavior an urgent priority. Social psychologists have provided valuable insights into the nature of many of these phenomena over the past thirty years. More recently, a great deal of energy has been invested in applying our understanding of social phenomena to improve social environments. This multidisciplinary venture has come to be called **environmental psychology.** Environmental psychologists seek to find ways of improving the quality of people's environments by researching ways of improving public transportation systems, waste disposal systems, pollution control techniques, development and utilization of various energy resources, and so forth. Environmental psychology represents a new and exciting systematic attempt to use psychological knowledge to improve the lot of humankind.

Extending the Boundaries of the Psychological Laboratory

The final contemporary development we shall characterize is methodological in nature. Psychology began largely as an experimental laboratory science, with rigid and controlled methods of investigation patterned after those of classical physics. This kind of controlled experimentation has been considered the best form of research by many psychologists, especially in North America and England, throughout the twentieth century.

Such methods are indeed well suited for identifying the immediate causes (the *how*) of a phenomenon. But although laboratory experimentation can yield precise answers to *how* questions, many critics have identified some serious drawbacks associated with sole reliance on such methods.

The major drawback involves the unknown effects of an artificial laboratory environment on the individual being observed. Many laboratory experiments produce precise results, but perhaps they are results that are valid only in a laboratory setting. In other words, the results of laboratory experiments may not generalize to the "real world." If the long-awaited visitors from another planet were to base their knowledge of human behavior on observations of inmates at Folsom Prison, and their knowledge of nonhumans on observations of animals confined in the Central Park Zoo, said visitors might return home with a rather distorted picture of the behavior of Earthlings. In order to gain an accurate understanding of behavior, it is also necessary to observe it in natural, unconfined settings.

Recently psychologists have begun to diversify their methods in order to safeguard against the potential pitfalls associated with laboratory experimentation. There appears to be less "experimental chauvinism," and many more attempts to observe behavior in natural settings and to create laboratory environments which more closely approximate natural environments. It has become clear that the full richness of behavior can never be captured by relying solely upon restricted methods of study.

Investigating Behavior Scientifically

3

Observation and Hypotheses

Forming Inferences

Achieving Objectivity

Theoretically Integrating the Results

Basic Behavioral Research Methods

Understanding the Results of Observations

Describing Behavioral Data Statistically

Making Statistical Inferences

Supplement 1 Which Measure of Central Tendency is Best?

Chapter Preview

This chapter introduces the basic features of scientific method — *observing,* forming *inferences,* achieving *objectivity, communicating* results, and *theoretically integrating* results. We place special emphasis on objectivity, and explore several sources of bias in behavioral research and methods of reducing bias.

The chapter examines specific behavioral research methods — *retrospection, introspection,* and *observation.* The first two methods are not sufficient by themselves because of their subjective nature. The third — objective observation — can either be nonexperimental or experimental. Nonexperimental observation does not involve the control and manipulation of variables to determine their effects on behavior. Rather, the observer simply records behavior as it occurs in the natural environment of the organism, or within more structured unnatural environments. Experimental observation involves the systematic manipulation of suspected causes of behavior, the independent variables, in order to assess their effects on behavior, the dependent variable. Experiments are generally carried out in laboratory environments, but can be adapted to naturalistic field settings as well.

Observations are often quantified — expressed numerically — and analyzed *statistically*. Quantification increases precision and allows us to examine relationships between behavior and other events. Statistical analysis is used to describe data in an economical and precise fashion, and to determine how much confidence we can place in the data.

A number of different statistics can be used to describe various aspects of distributions of data. One important aspect of a distribution that can be described statistically is the distribution's *central tendency*. The arithmetic *mean*, the *median* (the point dividing a distribution in half), and the *mode* (the most frequently occurring score in a distribution) are statistics that measure central tendency.

Variability is another important aspect of a distribution that can be described statistically. Variability refers to the degree of cluster or scatter in a distribution. The *range* is the most straightforward measure of variability; it is the difference between the highest and lowest scores in a distribution. The *variance* and *standard deviation* are more widely used measures of variability than the range. The variance and standard deviation reflect the average amount of difference between the scores and the arithmetic mean in a distribution.

In addition to characterizing central tendency and variability, certain statistics are used to indicate the *relative standing* of scores in a distribution. The *percentile rank* is the percentage of scores that lie below a particular score value in a distribution. The *z score,* another measure of relative standing, indicates the distance between a given score and the arithmetic mean of the distribution containing the score.

Finally, there is a statistic which indicates the degree of linear relationship among two or more distributions — the *correlation coefficient*. The correlation coefficient can vary from 0 (no relationship) to 1.00 (a perfect relationship). In addition, the correlation coefficient can be positive, indicating a direct relationship, or negative, indicating an inverse relationship.

Certain statistical tests allow us to make inferences about a larger group (the population) based upon observations of a limited number of subjects (the sample). By using these tests we can determine whether findings obtained from samples are *statistically significant*. Statistically significant findings are those that have a *low* probability of occurring by chance.

In the supplement to this chapter we discuss how it is possible to convey a different picture of what is happening in a distribution of scores by using different statistics. With regard to measures of central tendency, the mean may be misleading when a distribution is small and highly skewed.

We have stated before that psychology is the scientific study of behavior. But although we have used the term *scientific* several times, up to this point we have not been very explicit about its definition. We have used it in contexts in which it implied a systematic or rigorous approach to knowledge. But what precisely is meant by *systematic* and *rigorous?* What are the essential ingredients of scientific method? What are the major advantages and disadvantages of various methods used to investigate behavioral phenomena?

The major features of **scientific method** as it applies to the study of behavior include *observing* behavior, making logical *inferences* about behavior, achieving *objectivity* in observing and interpreting behavior, *communicating* the findings and interpretations of an observation, and *theoretically integrating* the findings of many independent behavioral observations.

Observation and Hypotheses

Observation is the basic method of science. It implies not only *perceiving* a phenomenon (behavior in this case), but also *recording* it and, ideally, *measuring* it. Measurement is the assigning of numerical values to events, and it increases the precision and accuracy of our observations. Unfortunately, no matter how precise our observations are, the very act of observing may affect behavior in ways that are impossible to assess. In other words, scientists never perceive behavior in a completely natural or undisturbed state. They perceive *observed* behavior, and the effects of observation itself are an unknown.

It is rarely possible to observe animals at such close range, and it is certainly questionable whether their behavior could be assumed to be normal without additional observations during which the observer is unobtrusive.

Scientific observation is not haphazard or random. It is designed to answer questions or solve problems related to a particular phenomenon. The questions may be very general—for example, "What kinds of movements and activities characterize a particular species of birds?" Or they may be quite specific—for example, "How does stress affect the human need to affiliate with other individuals?"

Before they begin to observe, researchers often venture educated guesses about what they will find. These **hypotheses,** or predictions, like the questions on which they are based, can also be quite general or very specific. For example, a psychologist might hypothesize only that there *will* be a relationship between stress and the need to affiliate, without saying anything about the direction or nature of that relationship. This would represent a general, nondirectional hypothesis. Alternatively, the psychologist might predict that an increase in stress will bring about a corresponding increase in the need to be with others. This is a more specific hypothesis because the expected direction of the relationship has been specified.

Researchers do not form hypotheses out of the blue. Hypotheses are *educated* guesses because they are based upon existing theory and upon facts related to the phenomenon under investigation. We shall have more to say about theories, and the relationship between theories and hypotheses, later in the chapter.

Forming Inferences

An **inference** is a conclusion or deduction that follows from observational data, and that provides some insight into the data. Many times we want to learn about more than the concrete, easily observable, descriptive aspects of behavior, the *what* of behavior; we want answers to *how* and *why* questions as well. Typically we must *infer* such answers, because we cannot observe them directly.

Consider the following example. Psychologists interested in describing and understanding memory processes have discovered an interesting phenomenon. When people are given a list of several items, presented one at a time, and asked to memorize the list, they usually recall the initial items and the last items much better than those in the middle of the list. This is called the **serial position effect,** and we refer to the elevated recall for first and last items as **primacy** and **recency,** respectively (Figure 3.1).

The serial position effect is an observed fact. But what accounts for it? Many psychologists have inferred that recency comes about because the last items on the list have greater "memory strength" than items in the middle of the list. That is, the mental representations of the most recent items have not had as long to become degraded, or out of focus, so to speak; they are still in **short-term memory.** But if this is true, then why are the first items on the list also recalled better than the middle ones? Shouldn't the mental representations of items from the beginning of the list be even more degraded, since they are less recent than the middle items? How can we account for the primacy effect? One *inference* regarding primacy suggests that it reflects a different kind of memory than recency. According to this view, the initial items are more likely to enter **long-term memory** because they receive more undivided attention than the middle ones, and thus are easier to fix in memory.

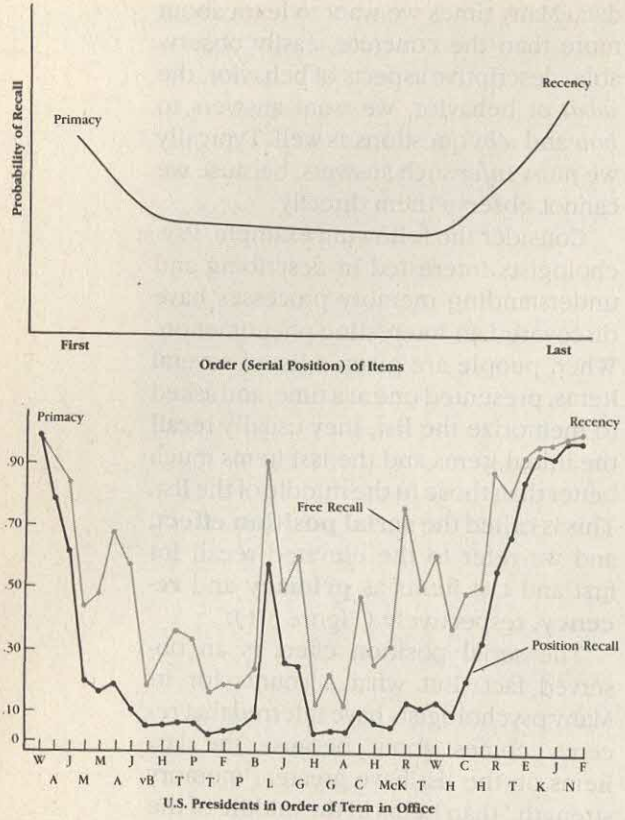


FIGURE 3.1 *(Top)* Idealized serial position curve showing primacy and recency as typically observed in free recall memory experiments. *(Bottom)* Serial position curve for recall of names of U.S. Presidents in a study involving university students as subjects. Free recall means that the President's name was recalled, but not necessarily in order of his term in office. Position recall means that the name was recalled in its proper position. In addition to primacy and recency, note the peak in the middle of the list. This would be expected only for an item that is in some way unique — in this case, Lincoln (L).

A point to note here is that inferences, such as those dealing with the serial position effect in our example, are not facts; they are tentative conclusions derived logically from the facts. They are important scientifically because they can suggest how and why a particular pattern of behavior occurs. They are also important because they provide a source of new questions and hypotheses, and can lead to further observations.

Achieving Objectivity

To be objective requires that we not let preexisting beliefs, attitudes, and feelings influence our observations and conclusions. Scientists strive for objectivity in order not to be deceived in their quest for the *what, how,* and *why* of a phenomenon.

Anyone who has ever tried to analyze the dynamics of a love affair while still involved in it knows how difficult it is to be objective about behavior. But objectivity is difficult to attain, even for scientists operating within the confines of the laboratory. Sometimes the investigator may look for — and find — only those aspects of behavior that conform to prior expectations, while unintentionally or intentionally ignoring equally important data that do not conform. Or the investigator's use of observational and reporting techniques may be so sloppy that bias simply cannot be ruled out. Some of the major sources of bias in behavioral research include: (1) defining or specifying a psychological phenomenon of interest in a vague or imprecise way; (2) relying totally upon subjective research methods; (3) recording and measuring behavior in imprecise ways; and (4) forming inferences or conclusions not supported by the data.

Operational Definitions

An important step in achieving a scientific understanding of a phenomenon is to specify that phenomenon in concrete terms. Those things which are under observation should be described and defined precisely enough so that other researchers can observe and record them in the same way. Vague definitions cause disagreement and confusion over *what* is being observed, and therefore allow bias to affect observations and inferences right from the start.

Unfortunately, this source of bias is perhaps a greater problem for a science of behavior than for any other science. This is so because behavioral scientists do not function as disinterested observers of phenomena "out there," but as observers of the very phenomena that characterize them as individuals. Essentially, behavioral scientists are *participant-observers,* and as such they may have many more preconceived definitions and interpretations of their subject matter than would, say, a botanist about mechanisms of plant growth, or a physicist about the behavior of subatomic particles.

Consider anxiety as an example of a psychological trait that can be difficult to define objectively. An unwary observer might be satisfied with characterizing anxiety as fear, dread, feeling uptight, or feeling apprehensive, because these are familiar ways of depicting anxiety in casual conversation. Now suppose two observers want to investigate anxiety among university students living in dormitories. They work independently, recording instances of anxious behavior in a group of dorm students. Let's say the observers use the vague characterizations of anxiety mentioned above to guide them in recording anxious behavior. As you might expect, it would be quite surprising if the observers were able to agree on what constitutes a single instance of anxiety, let alone on how they should go about measuring anxiety. Clearly, these observers need to discard their original subjective descriptions and define anxiety in a way that allows them to reach an acceptable level of agreement in their recordings. They need to define anxiety as objectively as possible.

Definitions which satisfy the requirement of objectivity are called **operational definitions.** Operational definitions list observable criteria that can be used to identify the phenomenon. An operational definition of anxiety, for example, would include only those characteristics that different observers can witness, record, and measure in a reliable—consistent—fashion. Our observers could have defined anxiety operationally as any detectable increase in heart rate, blood pressure, or sweating of the palms associated with a potentially stressful event, such as discussion of an upcoming exam. Or they could have defined anxiety in terms of students' responses to certain questionnaire items that have already been shown to successfully identify persons judged by clinical psychologists or psychiatrists to be anxious. Either of these definitions would be operational, because each specifies a set of observable criteria for identifying the phenomenon.

Operational definitions are often formulated in the process of answering *what* questions related to behavior, and they are essential for obtaining precise answers to *how* and *why* questions. Note that operational definitions are somewhat arbitrary; usually there is more than one way in which we can define a phenomenon operationally. In addition, no single operational definition can possibly represent all of the dimensions of a phenomenon, since it includes only a portion of those aspects that are observable. The great advantage of operational definitions is that they help avoid confusion and thereby increase the likelihood that observations and inferences will be accurate. In addition, they make it possible for other scientists to reproduce the original investigator's procedures and results. Scientific findings do not carry much weight if they cannot be reproduced.

Supplementing Subjective Research Methods

An example of a subjective method in behavioral research is **introspection.** Introspection involves looking inward and reporting on one's own inner mental or emotional states. We all introspect, and in fact introspection can be an important source of useful psychological questions and fruitful hypotheses concerning answers to those questions. But introspection becomes problematic when it is the *only* method used. One problem with the method is that we don't know whether introspective reports by experimental subjects reflect the subjects' true thoughts or feelings in an accurate way. For example, we can't be sure that when two or more subjects use the same words to describe their inner experiences they actually mean the same thing. Likewise, it is not clear that different terminology necessarily reflects different experiences. Of course it is also possible that subjects may not be truthful or may unconsciously bias their perceptions. Another problem with introspection is that it is difficult to know how to go about quantifying introspective reports. If scientific objectivity is the goal, then we must supplement introspection with methods that assess observable aspects of behavior.

There are procedures other than introspection that also leave much to be desired in terms of objectivity. Procedures that allow the *expectations* of the subject or of the observer to influence the outcome of a behavioral observation in an uncontrolled way are cases in point. For example, it is well documented that the results of some studies investigating the effects of drugs on behavior may have been biased because experimental subjects knew the nature or function of the drug they received. That is, the subject's *expectation* of what the drug would do, rather than the chemical action of the drug itself, may have been responsible for altering behavior. This is known as a **placebo effect.**

You may have witnessed or heard about practical jokes involving placebo effects. For example, a person is told he is drinking spiked punch at a party when, in fact, the punch has no alcoholic content. Yet, after three or four glasses, the person becomes less inhibited, more vocal, more sociable and, seemingly, very "high." He's not faking; he really feels intoxicated. However, the mind-altering drug in this instance is not alcohol; it's the person's *belief* that he's been drinking alcohol.

Placebo effects have also been demonstrated scientifically by telling experimental subjects they will receive a tranquilizer, stimulant, or some other consciousness-altering substance (Figure 3.2). Instead, and unknowingly, the subjects receive a *placebo*— a salt solution, sugar pill, or other substance that does not in itself have any significant physiological effect. A placebo effect is said to exist if the subjects begin to react in a way that mimics the effects of the substance they thought they were taking.

What can be done to eliminate the causes of placebo effects? Probably nothing. How could we ever keep an individual from entertaining expectations about a drug that he or she is going to receive, or about the purpose and nature of the experiment itself? On the other hand, it is possible to determine the existence of placebo effects, as we have seen. It is also possible to avoid creating the expectations that are responsible for these effects. Scientists have devised **single-blind** and **double-blind** techniques to control for bias related to both subject and observer expectations. The idea behind these safeguards is that the subject (single-blind), or the subject and the observer (double-blind), are kept in the dark with respect to the particular treatment that the experimenter will administer. Studies investigating the effects of various consciousness-altering drugs typically use (or should use) double-blind procedures. In such studies one group of subjects receives the experimental drug and another group the placebo. None of the subjects know what they have actually received, nor do those observing their behavior. Therefore, any behavioral differences observed between drug and placebo groups would more likely reflect the effects of the drug itself, independent of subject or observer expectations. Note that single- and double-blind techniques do not eliminate expectations, but rather *equalize* them for the drug and placebo groups. You should also be aware that these techniques, although usually associated with drug studies, also can be used in other areas of research where subject or observer expectations might have biasing effects.

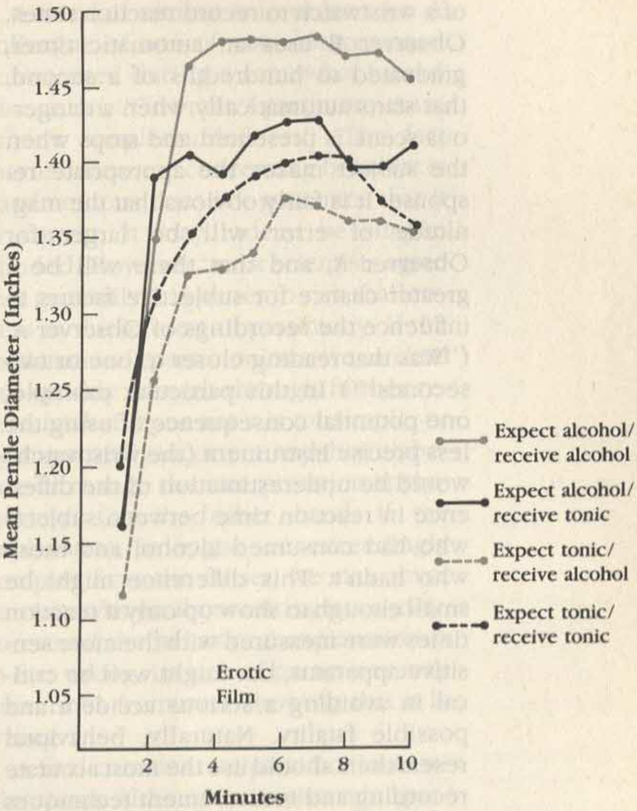


FIGURE 3.2 Placebo effect involving expectation of alcoholic beverage. In this experiment male subjects were placed in two "expectancy" groups—those expecting alcohol and those expecting tonic. Within each group half received vodka and tonic and half tonic only. Subjects were then shown films during which their penile diameters (a measure of sexual arousal) were recorded. The graph above shows pronounced arousal for all subjects during ten minutes of an erotic film. But how did alcohol affect arousal? As indicated in the graph, actual receipt of alcohol was not important in determining arousal. Rather, the *expectation* of alcohol seemed to be the important consideration. Those who expected alcohol and received alcohol *or* tonic showed more arousal than both groups expecting tonic—a placebo effect.

Precision in Recording and Measurement

Imprecision in recording and measuring behavior makes it easier for subjective judgments to influence observations. Consider an investigation of the effects of alcohol on driver reaction times to potentially dangerous highway or traffic conditions. The subjects are tested before and after they have consumed several ounces of alcoholic beverage, and two observers record the time it takes them to respond in an appropriate defensive manner to a visually presented danger. Observer A uses the second hand of a wristwatch to record reaction times. Observer B uses an automatic timer, graduated to hundredths of a second, that starts automatically when a dangerous scene is presented and stops when the subject makes the appropriate response. It is fairly obvious that the magnitude of error will be larger for Observer A, and that there will be a greater chance for subjective factors to influence the recordings of Observer A. ("Was that reading closer to one or two seconds?") In this particular example, one potential consequence of using the less precise instrument (the wristwatch) would be underestimation of the difference in reaction time between subjects who had consumed alcohol and those who hadn't. This difference might be small enough to show up only if reaction times were measured with the more sensitive apparatus, but might well be critical in avoiding a serious accident and possible fatality. Naturally, behavioral researchers should use the most accurate recording and measurement techniques available.

Logical and Parsimonious Inferences

It is a maxim of science that inferences should be deduced logically from the available data, and that vague or complex explanations of the data should be avoided. Assume that an ambitious graduate student specializing in child development is interested in tracking the social behavior of a group of preschool children from age two to age four. Thirty boys are observed at various times within this two-year interval, and the frequencies (number of occurrences) of certain behaviors are recorded during each observational session. The results of the observations indicate that one of the behavioral categories of interest—compliance with adult requests and demands—changes rather drastically with age. It turns out that when the children are two to three years old the number of "no" responses and other refusals to comply is much higher than at three to four. In writing up these observations for a thesis, the student investigator infers the following:

> The observed decline in negative behavior from 2½ to 3½ years in our sample indicates that children progress through a biologically determined stage that predisposes them to be more independent at the younger age. Undoubtedly, the 2½-year-old's experience of new-found freedom that results from mastering walking and the beginnings of language adds to this effect by allowing him to actualize his individual sense of self in an assertive and adaptive way.

As you may have noticed, our hypothetical researcher has gotten a bit carried away. There are instances of illogical reasoning here as well as vague and unnecessarily complex descriptions. For example, the investigator discusses the findings as if they apply to children in general, when in fact only boys were used as subjects. Perhaps the same phenomenon would not hold for girls. Another *non sequitur* (meaning "it does not follow") is the conclusion that a biologically determined stage is responsible for the increased negative behavior at age 2½. It is, of course, possible that biological factors caused changes in the children's temperaments during the one-year period, but the researcher has no data to show this. It is also possible that parents treat their children differently when they are 2½ than when they are 3½; perhaps the children's decline in negativity reflects changing environmental conditions independent of a biological stage. The problem here is that the investigator has gone beyond the data in forming conclusions. Note also that many terms are undefined, such as *stage* and *sense of self.* Finally, the last sentence of the quote is filled with subjective judgments regarding the children's perceptions and motivations. This is excess baggage and it violates a well-known rule in science, that of *parsimony.*

The term *parsimony* means frugality, thriftiness, or economy. A **parsimonious inference** is one that is economical in terms of the level of complexity used to explain the data. Consider another, perhaps more common example of a situation in which the inferences made often are not very parsimonious. Upon rising in the morning and walking into the kitchen, you notice your cat following at your heels, meowing and rubbing against your legs. What can you conclude about the cat's motivations from these observations? You might decide that the cat is motivated to behave the way it does because it realizes that you need a little cheering up before breakfast, and that providing this will ensure a decent meal for the cat. Such an interpretation lacks parsimony because there are simpler explanations available; for example, that the cat has acquired this sequence of behaviors because in the past it has paid off in terms of getting food and water. Note that in this second explanation there is no suggestion that the animal anticipates the consequences of its actions or is aware of your disposition — rather sophisticated abilities to ascribe to a cat. Note also that we can test the second explanation empirically with the hope of getting some clear-cut answers. Generally speaking, the more complex the interpretation, the more difficult it will be to determine its validity in an objective manner.

A word of caution is in order here. A colleague of one of your authors once commented during a somewhat heated discussion, "One man's parsimony is another's simplemindedness!" The fact that an inference concerning behavior is parsimonious does not guarantee that it is correct; it may indeed be simpleminded. However, most scientists agree that generally it is better to risk shallowness in the interest of parsimony. If the explanation is parsimonious, we can find out quickly enough through further research whether or not it is *too* simple, or perhaps totally incorrect, and then elaborate or change the interpretation appropriately. On the other hand, if the explanation is vague or exceedingly complex from the outset, we may never know how to go about testing its validity. So even if the behavioral explanation is in fact wrong, its lack of parsimony may prevent us from ever showing that it is wrong.

A final comment on parsimonious explanations: Although scientists value parsimony, it should be clear that there are no absolute standards for deciding what is or is not a parsimonious explanation. Different theoretical orientations sometimes dictate different standards for making these judgments. For example, a behavioristic psychologist may think that human problem-solving behavior can be explained adequately by arguing that it is a conditioned response to a set of complex stimuli. For this behaviorist, it is unparsimonious to use *cognitive* concepts to explain problem-solving. In contrast, a cognitive psychologist may find the behaviorist's explanation inadequate. For this psychologist the most parsimonious explanation will still need to involve such concepts as cognitive representation, attention, memory, and decision-making.

Communicating the Results

No matter how compelling and provocative a set of behavioral data may seem to the observer, it really isn't worth anything scientifically unless other people know about it. It's a bit like the sound made when a tree falls in the forest and there's nobody around to hear it. Specifically, communication of scientific findings establishes a public record. That record helps avoid redundancy and duplication of effort; it makes it possible for other researchers to test the results and extend scientific knowledge; it allows for the integration of findings and the discovery of systematic relationships that are broad in scope; and it permits others to use scientific knowledge to benefit society.

There are traditional forums and formats for communicating scientific information. It is commonly done via formal and sometimes highly technical reports given at local, regional, national, and international research meetings or conventions. Scientific information is also published in technical journals and books. Some major psychological journals are listed in Table 3.1

TABLE 3.1 Some Major Psychological Journals

Journal	Topical Area
American Psychologist	General psychology; business of the American Psychological Association.
The British Journal of Psychology	General experimental psychology.
Canadian Journal of Psychology	General experimental psychology.
Child Development	Psychology of child development.
Cognitive Psychology	Human cognition.
Contemporary Psychology	Reviews of psychology books.
Developmental Psychobiology	Biological aspects of nonhuman and human development.
Journal of Comparative Psychology	Animal behavior.
Journal of Consulting and Clinical Psychology	Clinical psychology.
Journal of the Experimental Analysis of Behavior	Analysis of operant (instrumental learning) principles of behavior.
Journal of Experimental Psychology	General psychology; learning, memory, and cognition; human perception and performance; animal behavior processes.
Journal of Personality and Social Psychology	The psychology of personality; social psychology.
Journal of Verbal Learning and Verbal Behavior	Human learning and memory; language.
Memory and Cognition	Human memory and cognition.
Perception and Psychophysics	The psychology of perception.
Psychological Bulletin	Critical reviews of research in all areas of psychology.
Psychological Review	Theoretical articles pertaining to all areas of psychology.

Theoretically Integrating the Results

The last feature of scientific method is an extremely important one. Essentially, integrating results means theory building. A **theory** is a formalized statement that tries to bring about a more complete understanding of the results of numerous observations carried out by different researchers. It accomplishes this by organizing often diverse scientific findings; by extracting certain principles from the data that may apply to a variety of different situations; and by formulating predictions derived from these principles that can be tested. The theory then stands or falls depending on whether researchers can verify its predictions.

It sometimes appears that scientists do the research first, and then construct theories to make sense of the data. This kind of sequence does happen, but often theories guide research activities by their predictions. It should be emphasized that theories are *tentative* explanations, continually subject to modification or even abandonment. Students in beginning psychology courses often want to know which is the "correct" or "true" theory of personality, learning, or some other set of psychological phenomena. There are no correct or true theories, however, because theories attempt explanations when all of the facts are not yet known. A theory is an integrated system of hunches concerning the how or why of a phenomenon. A police detective constructs a theory about the mechanics of a murder and the motivation for the crime in order to integrate and make sense of existing data such as the caliber of bullet found in the victim, the time of discovery of the body, the location of the body, and the information about individuals who would benefit by the victim's death. The detective's theory also serves to direct the search for further evidence. But if a witness turns in a videotape of the murder taken while it was in progress, so that all the facts of the crime are now publicly verifiable, then there is no more need for the detective's theory. The case is closed.

Of course, it rarely happens in science (or in crime detection) that research turns up such conclusive evidence. More typically, researchers discover a few empirical fragments and construct the outline of a puzzle (the theory) so that it will accommodate these fragments. As more of the fragments or pieces are accumulated, the puzzle framework may be elaborated, modified, or done away with in favor of a new framework.

Theories consist of *assumptions* that are not directly testable and *hypotheses* that predict what should happen if the assumptions of the theory are correct. For example, some psychologists and educators have theorized that certain specific learning disabilities, such as special difficulties in reading or math in spite of average or above-average general intelligence, may be caused by brain damage that is undetectable—so-called minimal brain damage. Since the damage cannot be detected using current methods, it is an assumed or inferred condition. We call conditions or entities that are inferred, like minimal brain damage, *theoretical* or *hypothetical constructs.* Since we cannot observe such constructs directly, we form hypotheses that follow logically from the nature of the construct. For example, we might hypothesize that such children would be more likely than children without learning disabilities to have encountered circumstances that could have produced brain damage. Such circumstances might include a difficult birth during which the child may have experienced a shortage of oxygen to the brain, accidents in which the child received a blow to the head, excessively high fever, or convulsions. If after careful investigation we find that this prediction is confirmed, we would then have support for the minimal brain damage theory. Please note, however, that this would not constitute direct proof for the existence of brain damage, only circumstantial, suggestive evidence.

We should point out that there are good theories and some that are not so good. How do we judge the worth of a scientific theory? First, the assumptions (and constructs) of the theory should be logical and not contradicted by existing facts. Second, the hypotheses should be derived in a straightforward manner; that is, they should follow directly from the assumptions that are made. Third, the theory should be parsimonious—its constructs should not be unnecessarily vague or complex. Fourth, and most important, the theory should be *falsifiable.*

This means that the theory should be specified in such a way that it can be *proven wrong* if it *is* wrong. Remember, a theory is a tentative explanation. We can determine its accuracy only by testing its predictions. If the theory's constructs or predictions are specified vaguely, or if the theory is so broad in scope that it can explain virtually any finding, then we cannot determine its validity in a scientific fashion. It may be enlightening and challenging for you to apply the criteria for an acceptable theory to the theories you encounter throughout the remainder of the text.

A final word about theories in psychology is in order. Although early psychological theorists often proposed all-encompassing explanations of behavior —Freud's psychoanalytic theory is an example—this trend is not as apparent in contemporary psychology. Early theories typically tried to account for too many psychological phenomena, and so were not very precise or accurate in their predictions. The vast complexity and variability of behavior have demanded that theoretical efforts focus on smaller and more manageable segments of behavior. As a result, psychology today is characterized more by mini-theories and models of behavior such as the information-processing model mentioned in the previous chapter.

Basic Behavioral Research Methods

So far we have discussed those principles of scientific method that underlie *all* scientific endeavors, not just psychology. Of course we used behavioral examples, and tried to emphasize those aspects of scientific method that are especially relevant to a science of behavior. Our discussion now turns to those specific methods of "doing" science that are employed in the psychological and biological sciences of behavior.

Introspective Research

We have already discussed introspection in the context of the history of psychology, and as a subjective procedure in our discussion of the features of scientific method. We would only underscore here a point made earlier. Introspection can be an important source of basic and applied questions about behavior and possible hypotheses related to those questions. However, because of its *private* nature it presents serious problems for a completely scientific, and therefore *public,* analysis of behavior.

Retrospective Research

To *retrospect* means to look back, and this is the defining feature of the second behavioral research method we shall discuss. In retrospective research the focus is on a person's past behavior. The method may be quite structured and involve the use of questionnaires, or it may be less formal, using interview techniques. A well-known study by Sears, Maccoby, and Levin (1957) designed to assess the effects of various child-rearing techniques is an example of the more structured retrospective approach. The researchers asked mothers to report on the kinds of toilet-training techniques they had used with their children, whether or not they had breast-fed their children, and other topics related to child rearing. The study was retrospective because it required parents to recall the techniques they had used in the *past.* The famous Kinsey studies (1948, 1953) of reported sexual practices in men and women are another example of retrospective research.

Retrospective research often is used for directly applied, particularly clinical, purposes. In order to understand and treat a person's behavioral problems, it is necessary to gain as much relevant historical data as possible. In this enterprise, called a **case history,** the investigator seeks background information from interviews with the person and his or her relatives, acquaintances, and other interested parties. As a result of this process, a case report is filed that will aid the clinician in understanding the problems the person is experiencing, and perhaps indicate some fruitful directions for treating the problems.

Although retrospective research can be useful and insightful, it is, as you might suspect, open to bias on the part of the subject as well as the researcher or clinician. A person's recall of past events is not always accurate for a variety of reasons, including memory lapses, unwillingness to reveal certain personal characteristics, desire to impress the interviewer, and desire to conform to current societal expectations. In addition, the interviewer may form interpretations that are influenced by subjective factors such as a strong commitment to a particular theoretical orientation, a desire to impress the subject or client, a desire to impress the research project director or clinical supervisor, and so on. Because of these problems, the results of retrospective research must be interpreted very cautiously, particularly if it is the only research method used in a particular situation.

Objective Observation: Nonexperimental

Although introspective and retrospective methods involve observation, they leave much room for bias and therefore are not objective. They have the further drawback that they can be used only with verbal, human subjects. To call an observation *objective* implies that the procedures used will allow different observers working independently to record the same events in the same way. Stated another way, objective observation produces results that are publicly verifiable.

Naturalistic Observation Naturalistic observation consists of observing behavior where it normally occurs — within the natural environment of the organism. It is the least obtrusive method, in that the observer makes every effort not to interfere with the behavior being observed. Naturalistic observation involves describing behavior (answering *what* questions), and is considered the *logical* starting point in behavioral research, although it has not always been the *actual* starting point. Naturalistic observation is essential for achieving a scientific understanding of an organism's normal behavior and how that behavior functions to adapt the organism to its natural environment.

Researchers can use a number of specific procedures when observing behavior in natural settings. These include making written or sound-tape narrative descriptions of behavior; recording the number of occurrences of a single behavior of interest; making frequency counts of large numbers of behaviors by using many observers, or multichannel recorders; and making videotapes or motion-picture films of behavior. This last procedure, although not always feasible or appropriate, can be particularly effective, because it captures a large spectrum of an organism's activities, it preserves far more of the dynamics of behavior than descriptions or records of numbers of occurrences can, it reduces recording errors, and it allows the observer the luxury of going back and picking up a great deal of information that otherwise would be lost.

Naturalistic observation has two distinct advantages. First, because it is relatively unobtrusive, naturalistic observation probably carries less risk of altering the behavior under investigation. Second, naturalistic observation would seem to offer a much richer and more realistic source of hypotheses for further investigation than either armchair speculation or observation in unnatural settings.

Of course, there also are limitations to naturalistic observation. One is that the observer cannot tell for sure which aspects of the external environment or of the organism are responsible for observed patterns of behavior. There are so many variables operating in the organism's natural environment that it is usually impossible to determine which ones are influencing behavior, and in what ways they exert their influence, at any given moment. Naturally, this does not prevent the observer from inferring the possibility of certain cause-effect behavioral relationships.

A second limitation on naturalistic observation concerns the difficulty of determining an organism's *competence* (what it is able to do) as opposed to its *performance* (what it actually does). Consider the problem we encounter in trying to assess intellectual capacities in certain nonhuman species such as apes by using naturalistic observation. Although this method has revealed provocative clues regarding ape intelligence, because of their uncontrolled nature these observations have not yielded clear and precise information on the nature and extent of this intelligence. Usually we obtain such information by studying an organism in a more controlled, and therefore unnatural, setting. For example, a number of controlled observations have shown that chimpanzees are capable of acquiring surprisingly sophisticated concepts resembling those of humans. This has been demonstrated in the chimp's acquisition and use of American Sign Language and other artificial communication systems. There is even evidence indicating that chimpanzees possess a certain level of self-awareness. We used to think that such indicators of intellectual competence were restricted to the human species. We would never have known that chimpanzees possess these capacities if we had depended solely on the method of naturalistic observation.

Observation in Unnatural Settings It is important to differentiate naturalistic observation from nonexperimental observation of behavior in places other than the organism's natural surroundings. Sometimes it is impractical or impossible to observe behavior where it normally occurs. It often is necessary to observe in a less complex and more structured setting, such as a laboratory, in order to identify specific factors that influence behavior. There are, nevertheless, problems that go along with observing behavior in unnatural settings. This is especially true when the research goal is to compile a catalogue of the typical behaviors of an organism, or to assess the ways in which behavior functions to adapt the organism to its environment. For example, it is now well known that the behavior of animals in captivity can be quite different from their behavior in the wild. The pacing that is so characteristic of many mammals in confined quarters, for instance, is typically not observed under natural conditions. Another behavior, aggression, appears to be much more frequent among captive animals in crowded conditions than it is in the wild. We might well be misled about the natural behavior of many animals, including humans, if we depended only upon observations of their behavior in captivity.

Observing behavior in unnatural settings also can pose problems for *applied* psychological investigations. Suppose a clinical psychologist wants to observe family members interacting with a disturbed child in a clinical setting. The psychologist witnesses the family's behavior from behind a one-way window which allows the observer to see in but not be seen. Suppose the observed interactions show nothing out of the ordinary, and reveal no clues as to which family-related variables may be contributing to the child's disorder. Even with these negative results the psychologist would be unwise to conclude that interactions in the clinic are necessarily representative of interactions in the home. Factors associated with the unnatural setting of the clinic, such as suspicion that one is being observed, may have completely altered the family's behavior.

Objective Observation: Experimental

In the typical psychology experiment, the observer manipulates an environmental factor that is suspected of influencing a behavior, while holding other possible influences constant. If the manipulation is accompanied by an orderly and reliable change in the behavior, the experiment is a success, because it has pinpointed a cause-effect relationship.

The factor that the experimenter manipulates is called the **independent variable;** other potentially influential factors that are held constant (controlled) are called **relevant variables;** and the outcome — usually a measure of behavior — is called the **dependent variable.** In a successful experiment, a behavior varies with — depends on — the different values of the independent variable. The experiment is the only observational method that allows us to infer that changes in the behavior under study, the dependent variable, are a direct result of changes in the independent variable, the factor that is manipulated by the experimenter. We can make this cause-effect inference because all of the other factors that could have accounted for the change in behavior have been held constant.

How does a researcher actually go about manipulating an independent variable? There are two major kinds of manipulation in behavioral experimentation: **between subjects** and **within subjects** (Figure 3.3). In both kinds of designs the experimenter first selects a **sample** of individuals representing some larger **population** of interest, such as university students, factory workers, albino rats, newborn infants, or rhesus monkeys. The population selected may depend upon the type of information desired, economic constraints, or ethical considerations.

The experimenter's next step is to decide upon the independent and dependent variables: the environmental factor that is to be manipulated, and the behaviors that will be observed in relation to

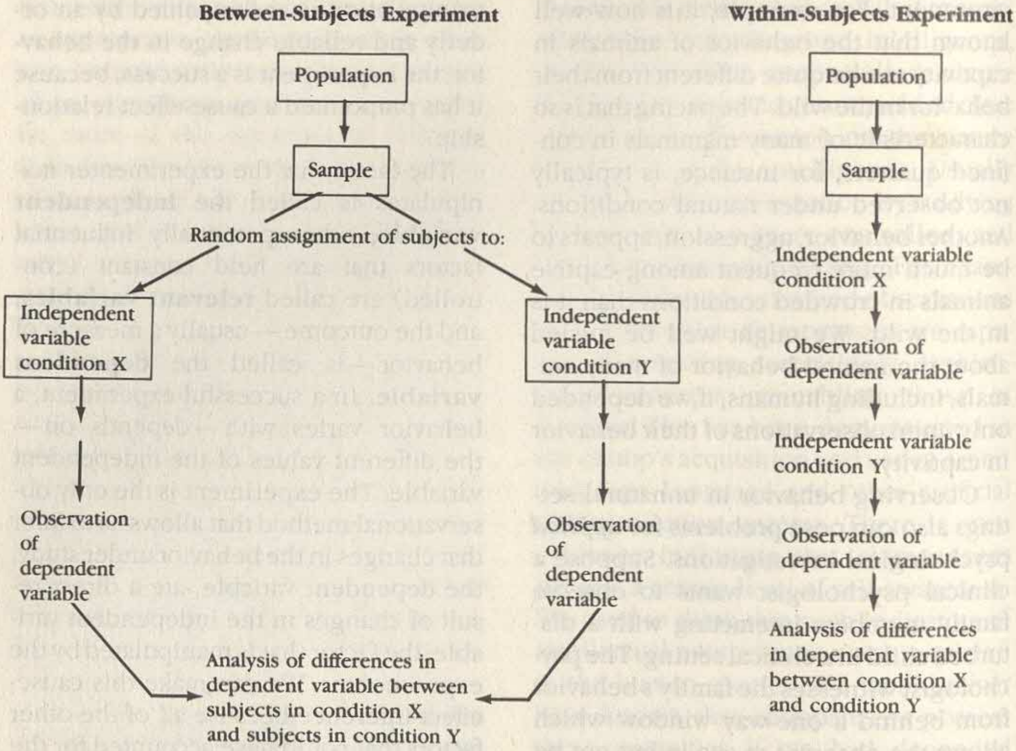

Between-Subjects Experiment
Population
Sample
Random assignment of subjects to:
Independent variable condition X
Independent variable condition Y
Observation of dependent variable
Observation of dependent variable
Analysis of differences in dependent variable between subjects in condition X and subjects in condition Y
Within-Subjects Experiment
Population
Sample
Independent variable condition X
Observation of dependent variable
Independent variable condition Y
Observation of dependent variable
Analysis of differences in dependent variable between condition X and condition Y

FIGURE 3.3 The steps involved in conducting between-subjects and within-subjects experiments.

that manipulation. Once this has been decided, the experimenter must determine whether the different conditions (levels) of the independent variable will be administered to *different subgroups* of the sample of subjects (between subjects), or to *each* of the subjects in the sample (within subjects). If the situation calls for a between-subjects design, the experimenter will assign subjects randomly to the different conditions of the independent variable.

For example, suppose an industrial psychologist wants to determine experimentally whether certain lighting conditions in a work setting will increase employee productivity and decrease accidents and errors. The independent variable is level of illumination (low, medium, and high) and there are three dependent variables — employee productivity, accidents, and errors. If the psychologist were to use a between-subjects design, the sample of employees would be assigned randomly to three different groups, each group receiving a different level of illumination during working hours. Then measures of productivity, accidents, and errors would be calculated for each subject in each experimental group, and the groups would be compared in order to determine which one was the most efficient and the safest.

If the psychologist chose to use a within-subjects design, *all* members of the sample would undergo *each* of the three levels of illumination. Measures of productivity, accidents, and errors would be calculated for each subject under each experimental condition. Note that here the experimenter compares the *same* subjects under each condition of the independent variable.

Within-subject comparisons generally allow for more precision in an experiment than do comparisons between subjects. This is because in the within-subjects design only the conditions of the independent variable differ. Everything else stays the same, including the subjects. But in the between-subjects design, not only do the conditions of the independent variable differ, but so do the subjects. Therefore between-subject performance comparisons reflect not only the differences in levels of the independent variable, but also differences between subjects.

So why ever use a between-subjects design if it is less precise? The major reason is that in some situations the within-subjects design has serious drawbacks. The major drawback concerns so-called **carry-over effects** associated with certain kinds of independent variables. Carry-over effects occur whenever the experiencing of one level of an independent variable "carries over" to affect performance under another level of that variable.

Experiments investigating the effects of certain drugs on behavior often have to contend with the possibility of carry-over effects. Let's say that an experimenter wants to determine which dosage level of a particular tranquilizer, Drug X, produces optimum calming effects on persons suffering from intense anxiety. The experimenter decides to test three different dosage levels of Drug X using a within-subjects design. Of course, to increase objectivity the experimenter would also need to include a zero-dosage level condition (no drug) and a placebo condition (a nondrug substance that is disguised as Drug X). The major point of concern here, however, is how to interpret the results of an experiment in which each subject undergoes each of the five conditions of the independent variable: three dosage levels of Drug X plus the no-drug and placebo conditions. If the experimenter observes a greater calming effect under the second dosage level administered (level b) compared to the first (level a), is it due *only* to level b? Or does it also reflect a residual or carry-over effect from level a? Generally speaking, it is better to avoid within-subjects designs when carry-over effects such as these are suspected.

Regardless of how a researcher manipulates an independent variable—between or within subjects—the distinguishing feature of an experiment is its emphasis on *control*. Experimental observation is the only observational method that controls (that is, systematically manipulates) a suspected cause of behavior, the independent variable. It also is the only kind of observation that controls other possible causal influences, the relevant variables, by eliminating them or by holding them constant. For these reasons, the experimental method is the most precise indicator of causes of a behavior.

At the same time, however, the control aspects of experimentation carry with them certain disadvantages. One is the increased risk of altering a subject's normal behavior so that what is observed may not be very representative of behavior under nonexperimental circumstances. This risk is particularly apparent in experiments carried out within the confines of a laboratory. University students who participate as subjects in a laboratory psychology experiment for the first time sometimes do so with all sorts of preconceived notions and anxieties

A psychologist and child involved in an experiment investigating how children form concepts.

about what will happen during the course of the experiment. Their concerns may affect their behavior in unpredictable ways. For example, the experimenter may find that when subjects are asked to learn a list of words in the presence of another person, they perform better than when they must do the task alone. In fact, a number of social psychological experiments have studied the effects of the presence of others on people's performance in various tasks, and some of them have reported the very result we described. But does this result reflect the state of affairs *outside* the experimental laboratory? Perhaps, but the subjects' awareness that they were under *experimental* scrutiny, and any concerns they may have had about this fact, *could have* produced an experimental outcome that would not be observed in the "real world." Laboratory experiments alone cannot provide us with a complete account of behavior.

Another disadvantage of the experimental method is that it is more restrictive than other methods; it can be used only in situations where experimental control is feasible. Sometimes, for example, it is not feasible to use the experimental method to study the behavior of certain animals in their natural habitats because of difficulties in tracking the animals, or in holding various aspects of their environment constant. Also, it is never advisable to use experimental manipulation in situations where it would be unethical to do so, such as experimenting with individuals against their wills, or manipulating variables that could be physically or psychologically harmful to an individual.

Even though experiments are carried out most easily in laboratory settings, it is sometimes possible to conduct experiments in more natural settings. A study carried out by Robert Furrer of Switzerland in the desert near Othello, Washington, provides an illustration of a simple experiment conducted in the field. Furrer did extensive research on Brewer's blackbirds, which in the research area only nest in sagebrush. There are numerous lakes and streams in the area, with various shrubs or small trees scattered here and there along the water's edge, but the blackbirds did not nest in them. Sagebrush grows in upland areas and to within a few feet of water, but not at water's edge. Furrer wondered why the blackbirds did not nest in the shrubs or trees along the water. Was it because the blackbirds there preferred sagebrush, or because the shrubs and trees were too close to and partially overhanging the water? Furrer drove stakes in a lake bottom several feet from shore, cut some sagebrush, and tied it to the stakes, thus making a loose clump of sagebrush in the lake. Blackbirds nested in the transplanted sagebrush, indicating that it was something about the sagebrush itself that they found more attractive than the trees or shrubs. Moreover, the fact that these birds nested directly over the water showed that proximity to the water did not deter nesting as long as the "proper haven," sagebrush, was available.

Another example of field experimentation is provided by Niko Tinbergen (1951), a famous ethologist. In observing a certain species of digger wasp that makes its home in the sand dunes, Tinbergen and others have noted some curious behavior. After the female digs a burrow in the sand which will serve as her nest, she leaves the burrow, closes the entrance by scraping sand over it, and flies away in search of bees which she will paralyze by stinging and place in the nest for her offspring to feed upon. Although this sequence of behavior is interesting in its own right, Tinbergen was more intrigued by what happens when the female returns to the nest to deposit her catch. In particular, he was impressed with the fact that she easily finds the hidden entrance to the nest upon returning from a sortie that often involves a good deal of distance and time away from the nest. How does the wasp find her nest so easily? Tinbergen observed that before leaving the area of the nest the wasp makes several semicircular passes over it. He hypothesized that these passes constitute a sort of orientation flight whereby the wasp rapidly learns the particular landmarks associated with the nesting site. In order to test his hypothesis, Tinbergen placed several pinecones in a circle around the nests of digger wasps. Then he waited until a female left her nest area. After her orientation flight he moved the pinecones from around the nest and placed them a short distance away. When the wasp returned sometime later she went directly to the center of the relocated pinecones, not to her nest. Tinbergen's hypothesis was supported; apparently female wasps of this species "memorize" the landmarks which are near their nests and use this information to find their way home.

Niko Tinbergen is a famous ethologist.

Field experimentation usually produces results that have more *ecological validity* than laboratory experimentation; that is, the results more likely represent what actually goes on in the organism's natural surroundings. However, such research may be less precise than laboratory experimentation because there is less control over the relevant variables.

An acquaintance with the various research methods we have surveyed will help you appreciate the way psychologists investigate behavior. In addition, you should be able to use some of the knowledge gained from this section to determine for yourself whether a researcher's conclusions or theories are valid in view of the methods the researcher used. For the purpose of investigating some phenomena, psychologists have devised special variations or applications of the basic research methods we have discussed. For example, methods used to investigate the development of behavior, the physiological bases of behavior, the inheritance of behavioral capacities, and the adaptive significance of behavior often require special adaptations. However, the basic principles — the concepts of objective observation, independent and dependent variables, experimental control, and so forth — stay the same. Therefore, you should have no difficulty understanding adaptations of these methods to particular problems discussed later in the text.

Understanding the Results of Observations

No matter which method a scientist uses to observe behavior, the end products of the observations are *data*— facts or information. How do behavioral researchers make sense out of the data they have collected? How do they analyze the relationships they observe between the environment and behavior, or those that exist among various behaviors? Most important, how do they determine the level of confidence they (and we) can place in their data?

Answers to these questions are provided by **statistics.** The term *statistics* has two meanings. First, statistics are *numbers* that summarize a phenomenon, such as batting averages in baseball, mortality rates associated with lung cancer, or the percentile ranking of an individual who has taken a university admissions test. Second, *statistics* refers to a highly technical branch of mathematics that is concerned with describing and analyzing data. Statistics are necessary for interpretation of data in psychology because of the substantial variations evident in behavior. Not all individuals behave in the same way, even when exposed to identical conditions. Thus we need a way to identify *general trends* in behavior from data that are sometimes quite variable. Statistical methods are a very effective and widely used tool for doing this.

Almost daily we are bombarded with statistics on TV and radio and in newspapers and magazines. Statistics abound, linking stress to cancer, obesity to coronary disease, crime to the unemployment rate, season of the year to incidence of various mental disorders, and on and on. In order to know how much confidence to place in findings such as these, and how to interpret them, it is necessary to understand the strengths and weaknesses of the methods used to gather the data and to know how to interpret the particular statistics used to describe the data. There is great potential for being misled or deceived by statistics if one knows nothing about their nature and limitations.

Describing Behavioral Data Statistically

Distributions and Graphs

Usually a researcher will have some difficulty interpreting a group of data (a *distribution*) without first depicting it in an economical and informative fashion. One common way of doing this is to construct a **frequency distribution.**

Table 3.2 shows a frequency distribution for the SAT scores of a group of stu-

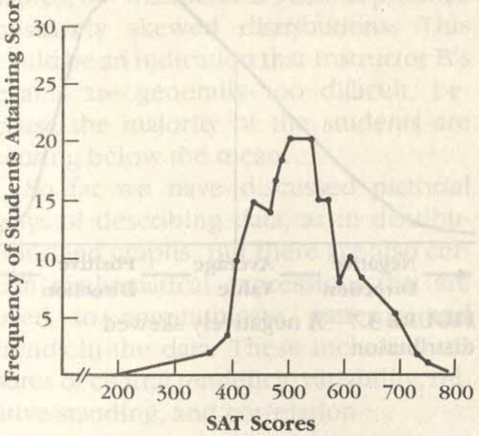


FIGURE 3.4 Frequency polygon for data in Table 3.2.

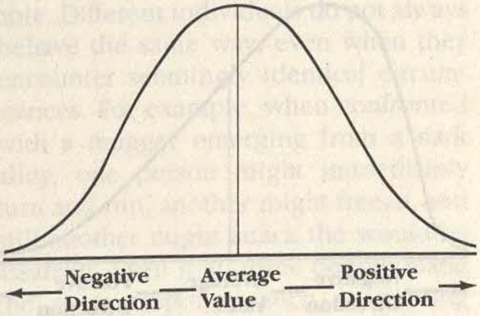
TABLE 3.2 Construction of a Frequency Distribution

Scores on the SAT College Entrance Exam	Tally of Students Who Attain a Particular Score	Frequency
760	|	1
740	||	2
700	𝍸	5
650	𝍸|||	8
630	𝍸𝍸	10
600	𝍸|||	8
590	𝍸𝍸𝍸	15
580	𝍸𝍸𝍸	15
560	𝍸𝍸𝍸𝍸	20
540	𝍸𝍸𝍸𝍸	20
520	𝍸𝍸𝍸𝍸	20
500	𝍸𝍸𝍸|||	18
490	𝍸𝍸𝍸|	16
480	𝍸𝍸||||	14
460	𝍸𝍸𝍸	15
420	𝍸𝍸	10
400	|||	3
380	||	2

dents. The score values obtained are listed from highest to lowest in one column, and the number of times each value occurs (its frequency) is indicated in another column. A frequency distribution is a very practical way to present the data if a large number of score values are repeated. Even more information becomes readily apparent if we *graph* the frequency distribution. To do this we first locate the score values on the **abscissa** (the horizontal axis) and the frequencies on the **ordinate** (the vertical axis). We then plot points to indicate how many times each score value occurred in the distribution. Finally, we connect the points with straight lines. The resulting figure is a **frequency polygon.** A frequency polygon for the data in Table 3.2 is shown in Figure 3.4. The shape of a frequency polygon can indicate several important characteristics of a distribution. For example, if we were to smooth out the frequency polygon in Figure 3.4 it would take on a symmetrical, bell-shaped appearance (Figure 3.5). This kind of distribution is called a **normal curve.** When a set of data is distributed normally, half the scores lie above the average score value and half below it, with the bulk of the scores clustering close to the average value. The average value is indicated by the vertical line passing upward from the abscissa to the peak of the curve in Figure 3.5.

Bell-shaped distributions are important because in nature many characteris-

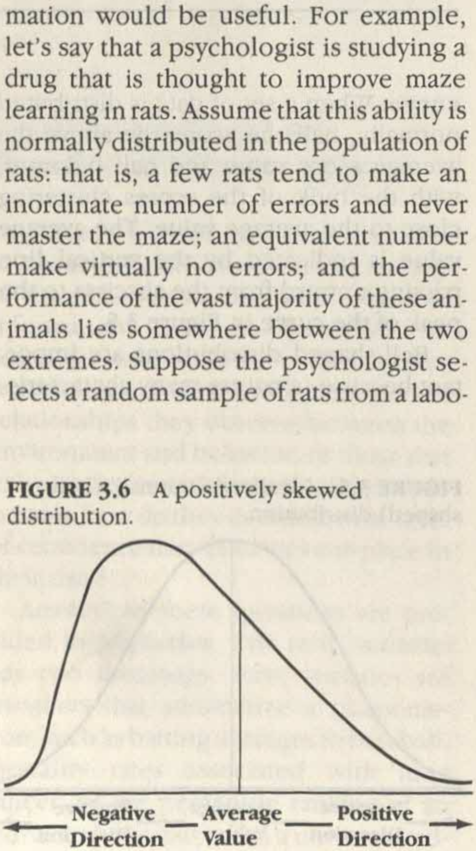
FIGURE 3.5 Idealized "normal" (bell-shaped) distribution.



tics do appear to be distributed normally, or approximately normally — for example, height, weight, wing lengths of a population of birds, and measured intelligence in humans. Moreover, many statistical tests used to analyze data are based on the unique relationships that exist in normal distributions, some of which we will discuss later.

Most distributions that are not normal in form are **skewed.** They can be skewed either in a positive direction (a majority of the scores lies *below* the average value — Figure 3.6), or in a negative direction (a majority of the scores lies *above* the average value — Figure 3.7). What is the value of knowing whether a distribution is skewed, and in what direction? In a number of situations this information would be useful. For example, let's say that a psychologist is studying a drug that is thought to improve maze learning in rats. Assume that this ability is normally distributed in the population of rats: that is, a few rats tend to make an inordinate number of errors and never master the maze; an equivalent number make virtually no errors; and the performance of the vast majority of these animals lies somewhere between the two extremes. Suppose the psychologist selects a random sample of rats from a laboratory-reared population, administers the drug to each member of the sample, and then tests each member in the maze. Suppose further that the resulting data are *not* normally distributed, but form a negatively skewed distribution, with more of the treated animals scoring above the mean, indicating that a majority of the animals tested do rather well in the maze. This would suggest that the drug may improve learning ability, even if the mean performance turned out to be the same as it was in the nontreated population. In this case the skewed distribution would suggest the need for an experiment to determine the extent of the drug's effectiveness.

FIGURE 3.6 A positively skewed distribution.



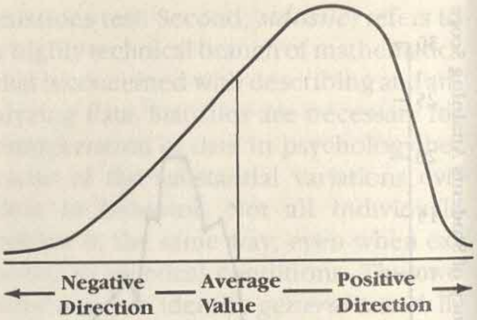


FIGURE 3.7 A negatively skewed distribution.

Another example that illustrates the value of knowing the shape of a distribution comes from the classroom. Let us say that two biology instructors are responsible for teaching a zoology course to two different classes of university students. Assume that the two classes are large and of equal size, and that the students in each class possess about the same range of intellectual ability, motivation, and interest in the subject. Each instructor covers the same material in lecture, at the same pace, and uses the same text. Instructor A's examinations consistently result in normal distributions of test scores, but Instructor B's exams produce positively skewed distributions. This could be an indication that Instructor B's exams are generally too difficult, because the majority of the students are scoring below the mean.

So far we have discussed pictorial ways of describing data, as in distributions and graphs. But there are also certain mathematical expressions that are used to communicate patterns and trends in the data. These include measures of central tendency, variability, relative standing, and correlation.

Central Tendency

The **central tendency** of a distribution is its balance point, so to speak. More specifically, the central tendency is the *average value* of a distribution of scores. Most of us are familiar with the kind of average often used in behavioral research, the **arithmetic mean.** The mean, usually symbolized by $\overline{X}$, is simply the *sum of* (Σ) the *scores* (X) in a given distribution, divided by the *number of scores* (N) comprising that distribution:

$$\overline{X} = \frac{\Sigma X}{N}$$

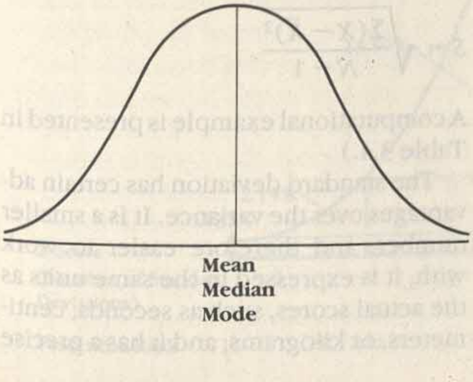


FIGURE 3.8 Normal curve showing location of different measures of central tendency.

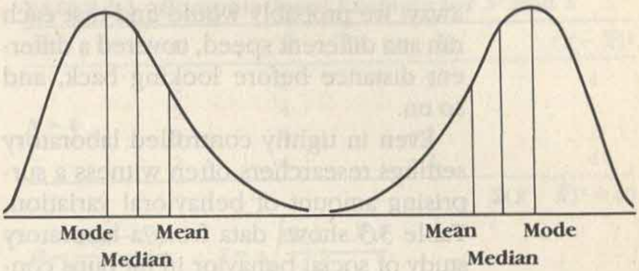


FIGURE 3.9 Skewed distributions showing locations of different measures of central tendency.

Other measures of central tendency include the *median* and the *mode*. The **median** is the point that divides a distribution into two parts such that 50 percent of the scores lie above it and 50 percent below. The **mode** is the score that occurs most frequently in a distribution. In normal distributions the mean, median, and mode all assume the same value (Figure 3.8). In skewed distributions they are different (Figure 3.9).

Variability

Although averages are very useful in describing trends or norms, they can also be misleading, because they do not reflect an equally important characteristic of distributions—**variability.** Our everyday experience tells us that behavior is often unpredictable because it is variable. Different individuals do not always behave the same way, even when they encounter seemingly identical circumstances. For example, when confronted with a mugger emerging from a dark alley, one person might immediately turn and run, another might freeze, and still another might attack the would-be assailant. Even if all three people made the same response, such as running away, we probably would find that each ran at a different speed, covered a different distance before looking back, and so on.

Even in tightly controlled laboratory settings researchers often witness a surprising amount of behavioral variation. Table 3.3 shows data from a laboratory study of social behavior in rat pups conducted by one of your authors and a colleague at Northern Michigan University (Hamm & Brown, 1978). We wanted to find out whether rat pups of various ages would spend more time with their own mothers than with mothers of other pups if given a choice. If they did, we thought this might indicate some ability on the part of the infant rat to recognize its mother, or vice versa. We observed each pup on two trials: one with the real mother housed in a cage to the left of the pup and the alternate mother to the right, and the other with the positions of the mothers reversed.

Table 3.3 shows the times spent in proximity to the real mother versus an alternate mother for each pup on each of the two trials in the twenty-four-day-old age group. As you can see, only a few scores are identical for the different pups, and some pups differed from each other by as much as 119 seconds in time spent with their own mothers. In addition, on the second trial some of the pups switched their "preferences" for mothers, while others did not.

TABLE 3.3 Variability in Scores

	Trial 1			Trial 2	
	Real Mother	**Alternate Mother**		**Real Mother**	**Alternate Mother**
Pup	*Seconds*	*Seconds*	*Pup*	*Seconds*	*Seconds*
1	120	71	1	124	27
2	122	33	2	89	47
3	37	13	3	115	24
4	5	90	4	73	89
5	43	68	5	106	36
6	31	64	6	37	87
7	60	66	7	68	0
8	62	71	8	111	40
9	49	83	9	108	49
10	73	36	10	76	67

Source: Hamm & Brown, 1978, unpublished data.

A number of statistics can be used to describe variability in a distribution. The easiest statistic to calculate, but the least sensitive indicator of variability, is the **range**—the highest score minus the lowest score in the distribution. The range reflects variability only in terms of the two most extreme values in a distribution; it tells us nothing about how closely packed or widely dispersed the other scores are. More precise and more commonly used measures of variability include the **variance** (S^2), and the square root of the variance, the **standard deviation** (S). Both of these statistics reflect a sort of average amount of difference between each score and the mean in a given distribution. (To compute S^2 or S, the mean is subtracted from each score. The resulting difference scores are then squared $(X-\bar{X})^2$ and added together: $\Sigma\,(X-\bar{X})^2$. This sum is divided by the number of scores in the distribution, N, minus 1:

$$S^2 = \frac{\Sigma(X-\bar{X})^2}{N-1}$$

and

$$S = \sqrt{\frac{\Sigma(X-\bar{X})^2}{N-1}}.$$

A computational example is presented in Table 3.4.)

The standard deviation has certain advantages over the variance. It is a smaller number, and therefore easier to work with; it is expressed in the same units as the actual scores, such as seconds, centimeters, or kilograms; and it has a precise relationship with the normal curve. As you can see from Figure 3.10, approximately 68 percent of the area of a normal curve (68 percent of the scores) lies between ±1.0 standard deviations from the mean; 95 percent of the area, between ±2.0 standard deviations; and over 99 percent of the area, between ±3.0 standard deviations. If a thousand people were given an IQ test, and we found that the mean IQ was 100 and the standard deviation was 15, we would know immediately that approximately 68 percent of the people taking the test (680 persons) scored between 85 and 115 (100 ± 15), because IQ is distributed approximately normally.

TABLE 3.4 Computational Example for S^2 and S

	X	$\bar{X}$	$(X-\bar{X})$	$(X-\bar{X})^2$
	6	4	2	4
	5	4	1	1
$N=4$	3	4	-1	1
	2	4	-2	4
				$\Sigma(X-\bar{X})^2=10$

$$S^2=\frac{\Sigma(X-\bar{X})^2}{N-1} \qquad S=\sqrt{\frac{\Sigma(X-\bar{X})^2}{N-1}}$$

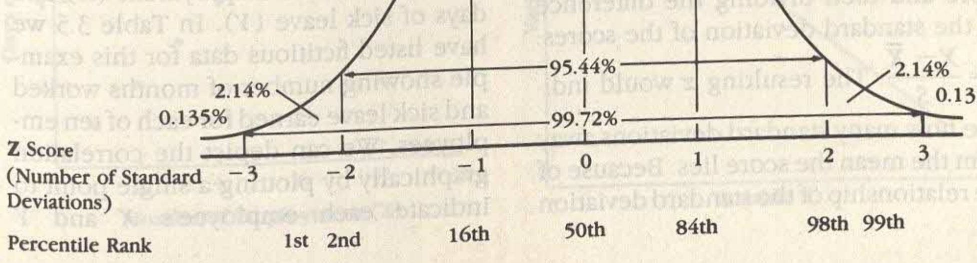
$$S^2=\frac{10}{3}=3.33 \qquad S=\sqrt{\frac{10}{3}}=1.82$$

Relative Standing

The relationship between the standard deviation and areas of the normal curve is also useful in determining the **relative standing** or location of any given score in a distribution.

Some instructors score students' multiple-choice exams by computer, and these computers usually are programmed to print out selected statistics related to the distribution of scores, such as the mean and standard deviation. If you took such an exam you might not be fully satisfied with knowing only your score, the mean, and the standard deviation. These statistics certainly would be helpful in describing the performance of the class as a whole, but undoubtedly you would want a precise indication of where your score is located relative not only to the mean, but to the other scores as well. Essentially, you would want an indica-

FIGURE 3.10 Areas of the normal curve related to standard deviations and percentile ranks.



tion of the relative standing of your score.

The most common way to locate an individual score in a distribution is by determining its **percentile rank.** A percentile rank indicates the percentage of scores that fall below a particular score value. The score value itself is referred to as the *percentile point* corresponding to a particular percentile rank. If your score received a percentile rank of 78, that would mean that 78 percent of the students taking the exam received lower scores. If your actual score was 37, then 37 would be the percentile point corresponding to the 78th percentile rank; it would be the value below which 78 percent of the scores in the distribution lie. Similarly, the median is a percentile point corresponding to the fiftieth percentile rank.

Recall that we said the standard deviation can be useful in determining relative standing. This is true if we are dealing with normal distributions, because of the relationship of the standard deviation to areas of the normal curve, which we have already discussed. It would be possible to determine the percentile rank of a score in a normal distribution by knowing only the mean and standard deviation of that distribution. We would simply need to convert the score of interest (X) to standard deviation units (called z scores). That is, we would need to determine about how far away from the mean (above or below it) X lies in terms of standard deviation units. We would do this by subtracting the mean from the score and then dividing the difference by the standard deviation of the scores: $z = \frac{X - \overline{X}}{S}$. The resulting z would indicate how many standard deviations away from the mean the score lies. Because of the relationship of the standard deviation to areas of the normal curve, we would then be able to determine the percentile rank of the score. (Appropriate tables have been constructed by statisticians for doing this.) Percentile ranks associated with z values of ± 1.0, 2.0, and 3.0 are illustrated in Figure 3.10.

Correlation

Up to this point we have discussed ways of statistically summarizing certain properties of a single distribution. But often researchers deal with more than one distribution, and they want to know specifically whether any relationship exists among two or more distributions. **Correlation** means relationship. If two things are correlated they are related in some way. More commonly, we speak of correlations existing among **variables** rather than distributions. Variables are quantities that may take on more than one value. A correlation between two variables X and Y would mean that changes in the value of X tend to be accompanied by corresponding changes in Y. A statistical correlation between two variables implies a *linear* relationship between the variables—a relationship that can best be depicted by a straight line.

A correlation is *perfect* if a change from one value to another on X is *always* accompanied by a change in the corresponding Y values. A company that provides its employees with one day of sick leave for every month of employment has guaranteed a perfect correlation between months of employment (X) and days of sick leave (Y). In Table 3.5 we have listed fictitious data for this example showing number of months worked and sick leave earned for each of ten employees. We can depict the correlation graphically by plotting a single point to indicate each employee's X and Y

values. Such a graph, indicating pairs of *X,Y* values, is called a **scatterplot** (Figure 3.11). It is apparent from our scatterplot that all of the points can be connected by means of a straight line. Whenever all of the *X,Y* points in a scatterplot lie in a straight line (assuming some degree of slope to the line), there exists a perfect correlation between *X* and *Y*.

The example above would also be an instance of a *positive* correlation, because *X* and *Y* change in the same direction—increases in *X* are associated with increases in *Y*. If two variables are correlated *negatively*, it means that there is an *inverse* relationship between the variables. That is, direction of change in *X* and *Y* is different; increases in *X* are associated with decreases in *Y*. Note that a negative correlation can be just as strong as one that is positive. For example, two variables could be correlated perfectly, but in a negative direction (Figure 3.12).

TABLE 3.5 Perfect Correlation of Months of Employment with Sick Leave

Employee	Number of Months Worked (*x*)	Number of Days Sick Leave (*y*)
1	2	2
2	10	10
3	1	1
4	3	3
5	6	6
6	5	5
7	4	4
8	7	7
9	9	9
10	8	8

Rarely, if ever, do behavioral researchers find perfect correlations among the variables they investigate. Table 3.6 shows some fictitious data representing two variables: *X* is the dominance rankings (status within the troop) of male rhesus monkeys; *Y* is the number of offspring each has sired. The major question here is whether there is a linear relationship between a male rhesus's status in a troop and his reproductive success. If so, how strong is the relationship,

FIGURE 3.11 Scatterplot for data in Table 3.5.

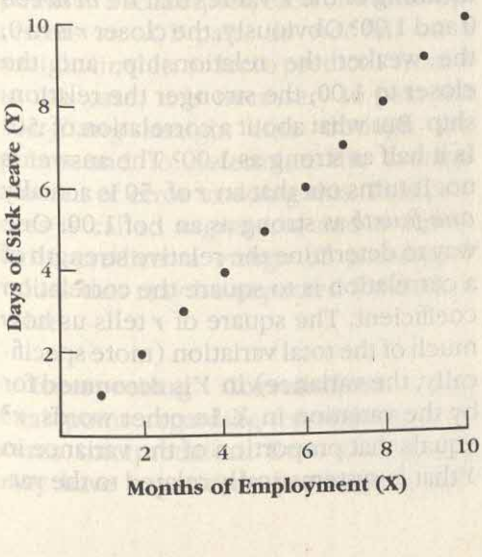


FIGURE 3.12 A perfect negative correlation.

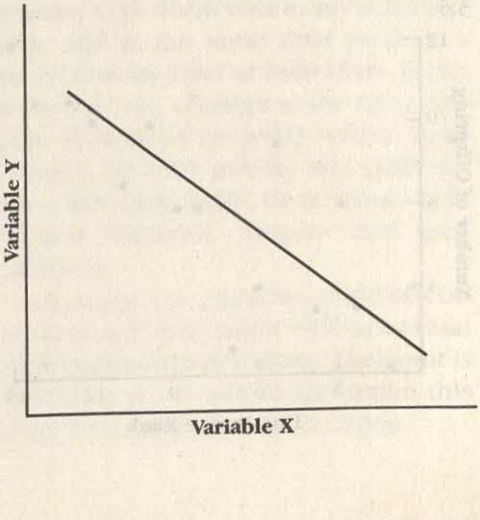
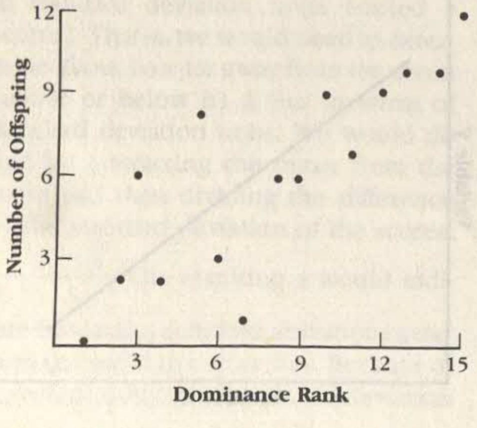


TABLE 3.6 Correlation of Dominance Rankings with Reproductive Success

Monkey	Dominance Rank (x) (1 = lowest; 15 = highest)	Number of Offspring (y)
1	6	3
2	14	10
3	3	6
4	1	0
5	11	7
6	15	12
7	4	2
8	2	2
9	9	6
10	10	9
11	5	8
12	8	6
13	13	10
14	7	1
15	12	9

and in which direction (positive or negative) does it lie? A glance at the scatterplot for these data (Figure 3.13) indicates that there is not a perfect correlation here, because the points do not lie in a straight line. However, the points are not scattered randomly either. With only a few exceptions, it does appear that monkeys with higher dominance sire more offspring than do less dominant individuals. What we need is a measure of the strength of this correlation.

FIGURE 3.13 Scatterplot for data in Table 3.6.



The Correlation Coefficient The statistic used to measure the strength of a correlation is called a **correlation coefficient.** There are different kinds of correlation coefficients, but the one most widely used is the Pearson Product Moment Correlation Coefficient, symbolized by r. The absolute value of r can vary from 0 (no correlation) to 1.00 (perfect correlation). A positive r indicates a positive correlation (a direct linear relationship), and a negative r indicates a negative correlation (an inverse linear relationship). Thus the absolute value of r tells us about the strength of the relationship, and the sign ± shows the direction of the relationship.

Returning to our example in Table 3.6, we can determine by means of a rather cumbersome formula that $r = .75$. Thus there is definitely a positive linear relationship between status and reproductive success. But just how strong is this correlation? In other words, what is the meaning of the r values that lie *between* 0 and 1.00? Obviously, the closer r is to 0, the weaker the relationship, and the closer to 1.00, the stronger the relationship. But what about a correlation of .50? Is it half as strong as 1.00? The answer is no. It turns out that an r of .50 is actually *one-fourth* as strong as an r of 1.00. One way to determine the relative strength of a correlation is to square the correlation coefficient. The square of r tells us how much of the total variation (more specifically, the variance) in Y is accounted for by the variation in X. In other words, r^2 equals that proportion of the variance in Y that is systematically related to the variance in X. If $r = .50$ then $r^2 = .25$; only 25 percent of the variance in Y is accounted for by changes in X.

Even though an r of .50 leaves a good deal of the variance in Y unaccounted for, it generally would be considered a moderately strong correlation in behavioral research. Obtained r values of .80 or higher are usually considered very strong correlations, but even when $r = .80$, 36 percent of the variance in Y remains unaccounted for. One major reason for considering r values of around .50 to be moderately strong has to do with their utility in *prediction.* If two variables are correlated, even moderately, it is possible to predict values of one from values of the other with some degree of accuracy. The accuracy depends upon the strength of the correlation. As r increases, the error associated with prediction decreases. If $r = 1.00$ there is a perfect correlation and there will be absolutely no error involved in prediction. Each predicted Y value will be a straightforward linear function of X. If you know an X value, you can predict — derive — the exact corresponding Y value.

If r is less than 1.00, it means that the points in a scatterplot, each of which represents an X,Y pair, do *not* fall on a straight line. In order to predict Y from X in this case, it is necessary to pass the *best-fitting* straight line through the points and to determine the average amount of error in doing this. This process is called *regression,* and it essentially predicts a *range* of possible Y values that may be expected for each X value.

Interpreting Correlations Our final point regarding correlation concerns interpretation. Even though we may have a perfectly predictable relationship between two variables ($r = 1.00$), we cannot infer that the changes in Y associated with changes in X are actually *caused* by X. In other words, a correlation, no matter how strong it is, does not imply a cause-effect relationship. The reason is that without manipulating one of the variables experimentally, such as varying X systematically while controlling other potentially relevant variables, there is no way to determine that it has a causal influence on Y.

To illustrate, consider the following hypothetical example. Suppose we find an r of $-.75$ between levels of anxiety in college students (X) and their performance on a complex problem-solving task (Y). This is a negative correlation, so it would mean that problem-solving skills tend to decline as anxiety increases. In other words, those students with relatively high anxiety levels would tend to do poorly on the task compared to those with lower anxiety levels. Would this mean that high anxiety causes an impairment in problem-solving performance? No. It could be just the reverse: an inability to solve problems with any degree of effectiveness might cause high anxiety. Or perhaps a third variable, such as a lack of praise or other rewards in the home or school, would result in a lowering of motivation to perform well in any academic task, and at the same time produce a more anxious kind of individual. If this were the case, changes in the third variable (history of rewards) would cause changes in both anxiety and performance, but there might be no causal connection between anxiety and performance.

Of course two variables could be correlated, and there might well be a causal relationship between them. The point is that there is no way to determine this from correlational evidence alone.

Making Statistical Inferences

We have seen that statistics can describe patterns, trends, and relationships in our data in an economical manner. In fact, the statistical measures we have discussed up to this point are referred to as **descriptive statistics.** But statistical methods can do more than describe data. They can provide us with a means of determining how much confidence we should place in the data. Statistics used for this purpose are referred to as **inferential statistics.**

"The task of statistical inference is to make a decision about what exists in a large group of cases (i.e., the population) on the basis of observations made from a small subset of cases (i.e., the sample)" (McCall, 1975, p. 166). This statement sums up nicely what is involved in making statistical inferences. Generally, researchers are not in a position to observe the behavior of entire populations: for example, levels of aggression in *all* preschool children exposed to TV violence; dominance rankings and their relationship to reproductive success in *all* male rhesus monkeys; levels of anxiety in *all* human adults who take Drug X. Typically, a sample of the population of interest is observed, and inferences are made about the total population based upon the sample observations. Inferential statistics gives us a quantitative way of determining the probability that what we have observed in our sample actually reflects the state of affairs in the population from which that sample was selected.

We can illustrate what inferential statistics allows us to do by using the example of a correlation discussed earlier in the chapter. Recall that we found a correlation of .75 between dominance rankings of male rhesus monkeys and number of offspring sired by them. Such a correlation indicates a positive linear relationship but, by itself, tells us nothing about the generality of the finding. Would similar correlations be obtained if other samples of male rhesus were observed? Or, more generally, does the obtained correlation of .75 for the single sample represent the state of affairs in the entire population of male rhesus?

In order to answer these questions we would need to conduct certain statistical tests. Inferential statistical methods include tests for estimating the probability that an obtained correlation is simply due to chance, that it is not reliable. There are also statistical tests for estimating the probability that a difference between the means of an experimental and a control group is due to chance. If by using such tests we determine that the probability of obtaining a particular correlation, a difference between two means, or some other statistic by chance is extremely low, then we conclude that the finding is statistically *significant.* In other words, the finding we obtained from a sample or samples probably is not a fluke; it is a finding that is reliable. How low must the probability of a chance finding be before we infer statistical significance? Generally, behavioral scientists agree that results which would occur fewer than five times out of a hundred by chance—p (probability) $\leq .05$—can be considered significant findings.

Thus if we found that the obtained correlation of .75 between male rhesus dominance and reproductive success would occur less than 5 percent of the time by chance, we would conclude that it was a *statistically significant* correlation. This would be reasonable assurance that our observations could be generalized to similar rhesus monkey samples.

Supplement 1. Which Measure of Central Tendency Is Best?

One thing about statistics that is very important to understand is that they describe *trends* in a distribution of scores. They do not necessarily typify any particular individual score. For example, an arithmetic average may have a value different from the value of any score in the distribution; that is, the average score may not exist in a distribution of scores ("There's no such thing as the average man"). In fact, the mean may or may not assume the same value as the other measures of central tendency (the mode and the median), as we saw in Figures 3.8 and 3.9.

So how do you know which measure of central tendency is best or most appropriate? The answer to this question depends upon certain characteristics of distributions, and upon what the person communicating the statistics intends to convey to his or her audience. If a distribution is very skewed—that is, if most of the scores are close in value to one another, but some scores are located a great distance from the others in one direction (Figures 3.6 and 3.7)—then the mean may not typify most of the scores in the distribution. For example, consider the following distribution of reported yearly income levels from individuals living in an urban neighborhood: $4,000, $6,200, $6,500, $7,000, $7,500, $8,500, $9,000, $42,000, $50,000. The mean income is $15,633.33, hardly typical of most income levels in this group. The median, however, is the middle value— $7,500. Half the incomes lie below this figure and half lie above it. In this case, the median is the more representative indicator of the central tendency of the distribution. When a distribution is highly skewed, the few extreme scores in a sense pull the mean toward them. In such cases the median, which is unaffected by the values of extreme scores, is the more appropriate measure of central tendency.

The mode usually is used only as a supplemental indicator to the mean or median. This is because many distributions either have no mode or have more than one mode. In these cases the mode either could not be used or would not be representative of the typical score in the distribution.

We mentioned earlier that the intentions of the person communicating the statistics also play a role in determining which measure of central tendency is most appropriate. It is possible to convey a different picture of what is going on in a distribution by using different statistics. For example, it may be important for a mayor seeking reelection to emphasize gains in employee wages and salaries; using the median income level of $7,500 for the example discussed above clearly would not serve that purpose. The mean of $15,633.33, however, implies a much better economic state of affairs than actually exists for most of the individuals sampled. The incumbent mayor's opponent in the election undoubtedly would be better off using the median income in order to paint the worst possible picture of income levels under the current administration.

Does this mean that it is possible to lie with statistics? The answer is . . . absolutely. There is great potential for misleading and deceiving the public through use of statistics. But the potential problems lie in the use and abuse of statistics, not in the statistics themselves. Statistical techniques allow us to describe and interpret data in an economical and quantitative fashion, and they are not about to be abandoned by the disciplines that depend heavily upon them. Statistical analyses of data are used by nearly all of the social, physical, and health sciences, as well as by government, business, and industry. The more you know about statistics, the better able you will be to avoid being duped. Weinberg and Schumaker (1969) bring this point home in the following passage:

> The fact is that the science of statistics is an enormously powerful tool to facilitate learning. But, like any powerful instrument, it may be used to increase man's effectiveness and happiness or it may be abused through conscious distortion for ulterior motive. One must remember that it is not the statistical approach that is at fault, but rather it is individuals working in large organizations who often abuse this approach for the organization's purposes. . . . Where there are abuses, the situation is not that figures lie but that liars are apt to figure. The solution is for the intelligent reader to be able to figure too (p. 8).

Origins of Behavior

Chapter 4 **Evolution and Behavior**

Chapter 5 **Heredity and Behavior**

Chapter 6 **Developmental Processes and the Beginnings of Life**

UNIT II

Basic to an understanding of behavior is an acquaintance with the fundamental biological forces that have helped to shape all living organisms. Most scientists accept the theory that the millions of species of animals and plants existing today are the products of perhaps billions of years of evolution on earth. Also accepted is the idea that evolution has proceeded, and continues, by means of natural selection, a concept that is Charles Darwin's major contribution. Those individuals with physical and behavioral characteristics best suited for coping with their environments are the ones most likely to survive and reproduce, thereby passing on the hereditary bases for such traits to the next generation. Thus those that are better adapted are selected by the environment to be the parents of the next generation.

Why do humans and other animals possess particular behavioral capacities and tendencies? We believe that a consideration of the basic principles of evolution can be helpful in trying to answer this question, and in appreciating the lengthy biological history of human behavior.

The basic units of heredity that may be selected for transmission from one generation to the next were unknown to Darwin. However, biologists now know a great deal about these units — genes — and about how they work to produce regularities and variations in characteristics. Genetic instructions, contained in the DNA of each cell, influence the emergence and development of all traits in all living organisms. This is easily seen in the case of human physical characteristics such as the development of the bones, muscles, and organs of the body, and in variations in eye color and skin color. But it is also true that behavioral characteristics such as intellectual and personality traits depend on genes for their expression.

This is not to deny or minimize the contributions of the environment, which has a crucial bearing on the development of genetically coded characteristics. For example, the idea that genes could "build" a nervous system without an environment is preposterous. There must be an environmental medium in which the genes can carry out their instructions. In addition, events in this medium can influence the way in which genetic instructions are executed. For instance, certain viruses present in the intrauterine environment can result in faulty development of the central nervous system in an unborn child. In spite of what some people think, the environment is no more or no less important than genetic factors in structuring a trait; both are required.

In addition to an evolutionary (phylogenetic) history, individual organisms of every species have a developmental (ontogenetic) history. Developmental changes in humans begin almost immediately after conception. These changes are most rapid and dramatic before the baby is born. And although newborn humans are totally dependent on others for their survival, they have nevertheless developed some remarkable capabilities that can be observed immediately after birth. In contrast to the beliefs of the seventeenth-century philosopher John Locke, babies do not come into the world as a *tabula rasa,* a blank slate. Rather, they appear ready to perceive certain kinds of information, to learn from their environment, and to play an active role in developing a loving relationship with their parents.

Evolution and Behavior

4

Evolution by Natural Selection

Darwin's Theory

Evolutionary Change

The Evolution of Behavior

Evidence for the Evolution of Behavior

Coevolution of Characteristics

Supplement 1 What Is a Species?

Supplement 2 The Population Concept

Supplement 3 Speciation

Supplement 4 The Evolution of Humans

Chapter Preview

Evolutionary ideas have existed at least since the writings of Anaximander, but it was Charles Darwin's book *On the Origin of Species by Means of Natural Selection* (1859) that caused the idea of evolution to become widely accepted. Thus Darwin did not "invent" evolution; rather, he provided a logical explanation for how evolution works—by natural selection. Natural selection means that the environment favors those individuals of a species best suited to that environment; such individuals are much more likely to survive and produce successful offspring.

Evolution involves genetic change. Individuals are genetically fixed at the time of fertilization, but populations can evolve through time due to the mixing of genetic information from successful individuals.

Behavioral characteristics undergo natural selection just like anatomical and physiological characteristics do. Unlearned, genetically programmed behaviors are the result of a long period of natural selection. Learned behaviors are not genetically programmed or subject to natural selection, but the ability and inclination to learn them is genetically influenced and therefore subject to selection.

Behaviors are not preserved as fossils, nor are they observable in the developing embryo. In studying the evolution of behavior we are limited to comparisons among living species, but these studies offer a number of insights.

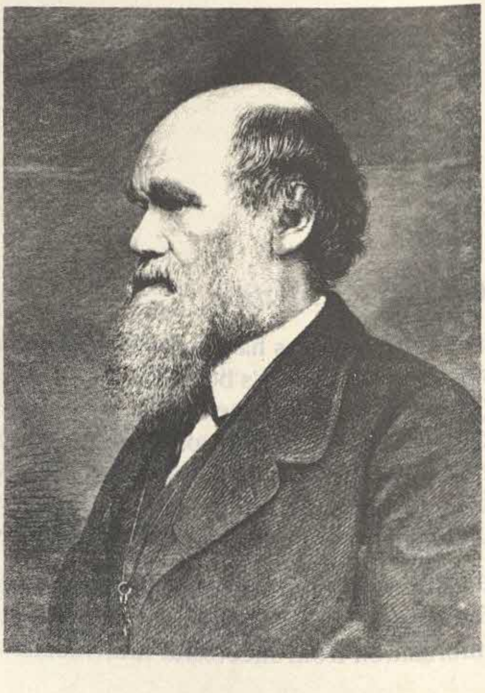
Characteristics sometimes coevolve. As a result of a change in one characteristic, a particular change in a second characteristic becomes favorable. If the second change occurs, further changes in the first characteristic are of advantage, and so forth. Thus behavior can affect structure, just as structure can affect behavior.

The four supplements to this chapter discuss the concepts of species, population, speciation, and the evolution of humans.

There are over two million different species of living things on earth, and until a little over a century ago most people believed each one had been separately created by a supernatural power. Even the young Charles Darwin, in reporting his experiences in various parts of the world, commented on the astounding amount of "creative force" that must have been expended to supply each of the Galapagos Islands with its own species of tortoise, sunflower, and various other plants and animals (1845). He puzzled over why the Creator would bother to put only slightly different forms of each type on the various islands. As long as He was going to bother at all, why not make each species *quite* different?

This questioning led Darwin to forsake creationism, and ultimately to publish the results of his ponderings in 1859. But Darwin was not the originator of the idea that all living things evolved from some remote common ancestor. We know from the writings of Anaximander (611–547 B.C.) that the idea of **evolution** existed in early Greek thought. Among other things, Anaximander proposed that life had evolved from moisture, and that humans had evolved from fish. Later the Roman poet Lucretius

Charles Darwin originated the idea that evolution occurs by natural selection.



(99–55 B.C.) came very close to Darwin's notion of natural selection in his work entitled *De rerum natura.*

> Every species that you now see drawing the breath of life has been protected and preserved from the beginning of the world either by cunning or by prowess or by speed. In addition, there are many that survive under human protection because their usefulness has commended them to our care. . . . They have gladly escaped from predatory beasts and sought peace and the lavish meals, procured by no effort of theirs, with which we recompense their service. But those that were gifted with none of these natural assets, unable either to live on their own resources or to make any contribution to human welfare, in return for which we might let their race feed in safety under our guardianship—all these, trapped in the toils of their own destiny, were fair game and an easy prey for others, till nature brought their race to extinction (Trans. by Latham, 1960, pp. 197–198).

For the most part evolutionary notions lay dormant during the Middle Ages and Renaissance, but began to receive increasing attention during the late eighteenth and early nineteenth centuries. Among their proponents during the latter period were Comte Georges Louis Leclerc de Buffon, Darwin's grandfather Erasmus Darwin, and Jean de Lamarck.

Charles Darwin presented exhaustive arguments related to the nature of evolution in his well-known book *On the Origin of Species by Means of Natural Selection* (1859). This work is commonly referred to as *The Origin of Species,* or simply as *The Origin,* designations that miss Darwin's major contribution. Darwin did not give the scientific world the idea of evolution, although he gave extensive evidence for evolution. Darwin's major contribution was his explanation of how evolution works: by *natural selection.*

Evolution by Natural Selection

Natural selection means that the environment determines whether an individual will live and reproduce or die without reproducing. Darwin's ideas about natural selection were based partly on his observations of **artificial selection.** In artificial selection, humans rather than nature select which individual plants or animals will breed, so as to encourage characteristics that are considered desirable. By breeding together only individuals with favored characteristics, it is possible to establish a breed or strain in which these characteristics are more pronounced. For example, higher milk production in dairy cattle is achieved by breeding only those that produce more milk than average, and by continuing this process over several generations. Each generation is increasingly more likely to encompass the desirable characteristic, and thus be better adapted to *human* demands.

Artificial selection has been instrumental in the development of a great many varieties of plants and animals for both food production and enjoyment (Figure 4.1). It has allowed humans to develop corn and wheat with larger seeds, race horses with longer legs, beef cattle with stockier builds, and docility in all domestic animals.

In view of the numerous **varieties** humans have produced by acting as the major selective force, Darwin reasoned: What humans can do in a relatively short time, nature can do more completely, given unlimited time. Humans have pro-

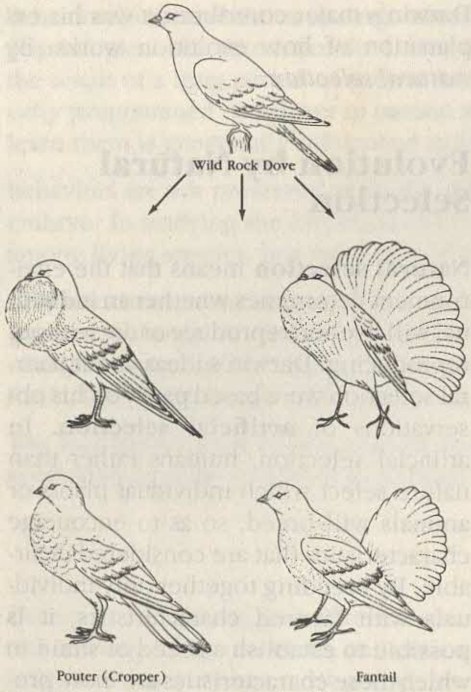


FIGURE 4.1 Three breeds of domestic pigeons showing their evolution by artificial selection.

duced varieties and breeds by *artificial* selection. Nature has produced varieties, and ultimately species, by *natural* selection.*

Darwin envisioned natural selection operating as follows: Individuals that have characteristics allowing them to be more successful in their environment than others of their species are in essence selected by that environment (nature) as parents of the next generation. Similarly, those that are less successful in obtaining food or mates, escaping predators, or whatever, tend to produce fewer offspring or none at all, and thus pass their characteristics to the next generation much less frequently.

Darwin's Theory

Darwin's explanation of how the process of natural selection works is based on four premises regarding living organisms. These points are the basis for modern thinking on evolution.

1. Variations exist in nature among the members of each species.
2. There is a tendency for a geometric rate of natural increase; more young are produced than environmental resources can support.
3. A struggle for existence occurs, partly due to excess numbers.
4. The struggle results in natural selection of the individuals with more favorable variations.

Now we will consider each of the points listed above in greater detail.

1. *Variations exist in nature* among the members of each species. This is easiest for us to see among humans. No two of us look exactly alike or behave quite the same, and we also have physiological differences. Differences exist among the members of every other species as well, as you can see by careful observation. This is because each individual of any species is genetically unique, with the exception of individuals such as identical twins which develop from the same fertilized egg.

2. There is a *tendency* toward a *geometric rate of natural increase,* a tendency to produce more offspring than the environment can support. In other words, more young or seeds are produced than can survive and grow to reproductive age.

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* A *variety* or *breed* is a group of plants or animals recently descended from common ancestors and similar in most characteristics. There are many breeds of dogs, for example, and striking differences among breeds. However, all breeds of dogs belong to the same species and are generally capable of interbreeding. *Species* is a more general category than variety or breed. Members of different species are sufficiently different in physical and behavioral traits that breeding between them does not occur under natural conditions.

For example, a tree in a dense forest may produce hundreds or thousands of seeds, but there is no space for them to grow. The rare seed that does sprout cannot get enough light, and the plant is tiny and stunted, or dies. Occasionally, however, a mature tree dies, leaving space and light for perhaps one seed to grow into a mature tree. Similarly, a mature female mouse may produce several litters of perhaps ten youngsters each, but few if any of the young will survive to reproductive age, and then only if some mature mice die.

Note that there is only a *tendency* to increase. An increase seldom occurs, and natural populations generally remain stable year after year with only slight fluctuations. Stability is reached at the population level that local environmental resources can support, and resources are limited. (It has probably already occurred to you that humans violate this premise. Because of advances in medicine, some people of all ages who would have died are kept alive.)

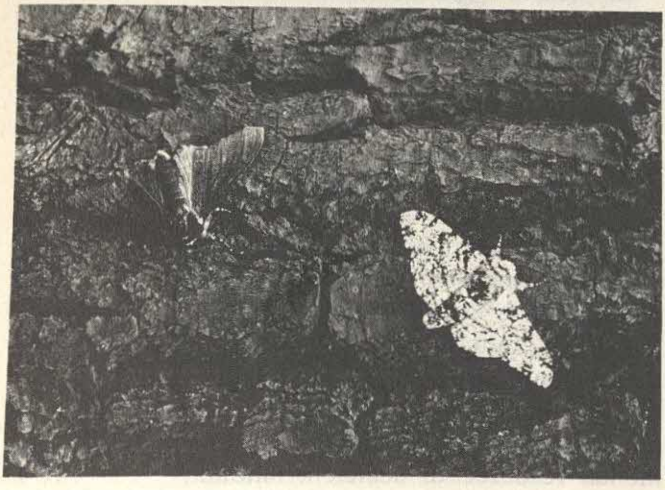
3. *There is a struggle for existence,* a struggle with many aspects of the environment. It is here that the importance of individual variation becomes apparent. Some individuals have characteristics, genetically based, that enable them to be better adapted to their environment and more successful than others of their species. They tend to have more offspring surviving to reproduce in the next generation, and of course the offspring also have these favorable characteristics. Darwin emphasized competitive and fighting behavior, and thought of the struggle for existence mainly as a tooth-and-claw, kill-or-be-killed sort of thing. Modern neo-Darwinian theory includes those ideas, but also considers the ability to tolerate various conditions in the physical environment, such as extremes of temperature and moisture, the ability to obtain resources from the environment (food, nesting sites), and the adaptiveness of other behaviors such as mate-finding and courtship—all of the things necessary for survival *and* reproduction. It is also here, under the idea of "struggle for existence," that the significance of the tendency for a geometric rate of natural increase becomes apparent. Reproduction sufficient to replace loss is essential if a species is to avoid extinction. Reproduction above replacement requirements may seem wasteful, but it has at least two distinct advantages. First, if a **population**—all the members of a species in a given area—declines in numbers due to bad weather or unusually heavy predation, the population can be rebuilt. Second, the production of many offspring that are all genetically different allows the population to remain well adapted to its environment or even improve in this respect by increasing the probability of favorable gene combinations.

4. The struggle results in *natural selection.* Every individual is different, however slightly, from every other individual, and some are more fit than others for survival in a particular environment. Thus the environment in effect selects individuals with more favorable characteristics to survive and pass on their genes to the next generation. Similarly, the environment selects against those that have less favorable characteristics. Those that cannot tolerate some environmental condition, such as heat or cold or the amount of light or moisture, or cannot obtain some necessary environmental resource in sufficient amount, whether due to competition from more capable individuals or a simple lack of ability, will not survive to produce offspring. Thus due to natural selection a population may not only survive, but may even improve its adaptation to its particular environment.

Evolutionary Change

Every individual is genetically fixed at the moment the sperm and egg unite. Evolution involves genetic change, and therefore individuals cannot evolve. Those that are not genetically suited to the environment where they hatch, sprout, or are born do not survive. Of course, most individuals are adapted to the local environment, because their parents were and they received their genetic constitutions from their parents. Still, some have more favorable genes or gene combinations than others.

FIGURE 4.2 The normal coloring of peppered moths *(Biston betularia)* blend with a lichen-covered tree trunk, but they are quite conspicuous on a soot-covered tree. The reverse is true for the dark form of the moth.



Natural selection favors individuals with certain genes and gene combinations over others, and the favored ones survive to produce the next generation, which in turn undergoes natural selection. Thus there is a change in the genetic constitution of a population through time. This is evolution.

In this way a population may improve in relation to the existing environment, or perhaps change along with a changing environment. If all the members of a species were genetically identical, there would be no variations to select from, and evolution would not be possible. This is not to say that change is inevitable. Turtles have not changed much in appearance or structure for about three hundred million years, some insects for about thirty million, but they did evolve from earlier forms that changed anatomically. We don't know what physiological changes may have occurred. On the other hand, the large dinosaurs failed to change, and became extinct.

An interesting example of the importance of variation in adapting to changing conditions is the peppered moth, *Biston betularia,* in England. These moths are normally pale with a peppering of dark markings. They rest on tree trunks that are covered with lichens, and the moths are rather difficult to see because their coloring blends with that of the lichens. Once in a while a mutant dark individual appears in a normal population, but does not last long because birds can spot it easily on the pale tree trunk and eat it. However, in areas with heavy industry the soot and smoke from factories have killed the lichens and darkened the tree trunks. In these areas the dark form of the peppered moth has taken over. Light individuals appear occasionally, but on the dark tree trunks they are easy prey for birds (Figure 4.2).

This is an example of natural selection in action. In this case environmental factors (birds) selectively destroy (eat) individuals that are not adapted to the local environment (do not match the background). It is evolution on a very small scale — the replacement of a gene for light color by another gene for dark color in areas where the tree trunks are darkened by industrial smoke and soot. The accumulation of a number of such changes in a population could ultimately result in a new species.

The Evolution of Behavior

Behavioral traits are under the same sorts of selective pressures as are other characteristics. The genes underlying the development of behaviors that give survival and reproductive advantages are passed on to future generations with a greater frequency than genes for less successful behaviors.

The unlearned, genetically programmed behaviors present in any species of animal are the result of a long period of natural selection. Learned behaviors are not genetically programmed, nor are they subject to natural selection, but certainly the ability to learn them and the inclination to do so is genetically influenced and therefore subject to selection.

Unlearned behaviors tend to be more typical of short-lived animals, although most have the ability to modify some of these behaviors by learning due to experience. In general, longer-lived animals depend less on unlearned behaviors and more on learning. This arrangement, if we can call it that, would seem to have survival value. For example, most insects overwinter in the egg stage, hatch after the parents are dead, mature in several days to a few weeks, reproduce, and die a few weeks later. Given such a short life span, and no opportunity to learn from parents or other experienced adults, it would appear that the best adaptive strategy (so-called — they don't plan it) would be to depend heavily on genetically programmed, unlearned behaviors . . . those behaviors that have been successful in the past, and that are often called **instincts.** On the other hand, for animal species such as humans and wolves that spend much time with adults of their species while maturing, a heavy reliance on learned behaviors would seem to be more valuable. Learned behaviors are highly adaptive, in that they allow relatively rapid adjustments to changing or unusual conditions that the genetic program cannot anticipate.

Bear in mind that learned and unlearned behaviors are not mutually exclusive. Most or perhaps all animals utilize both to some degree. However, animals that rely heavily on genetically programmed behaviors are relatively inflexible in dealing with some unusual environmental situations. Jean Henri Fabre's observations of caterpillars that feed on pine needles in France are perhaps an extreme example.

The pine caterpillars, or "processionaries" as they are called, simply follow the leader. The leader is whichever individual happens to start first. Remove the leader and the next in line becomes the leader. They stay in a nest on the ground at night and climb a pine tree to feed during the day. The leader lays down a silk-strand track, and the others follow it and add to it.

One day Fabre noticed a leader climbing the side of a large tub, and of course the others followed. Upon reaching the top, they proceeded to crawl around and around the rim. Fabre thought they

Jean Henri Fabre.

would come down after a while, but they didn't. They stopped in clumps at night, but continued to go around and around the rim the next day, and the next. On the fourth day a member of one of the clumps, not being on the silk trail, started down the side of the tub and four others followed; however, after descending about halfway they turned and went back to the rim, rejoining the caterpillars still circling the top of the tub.

On the eighth day, being very tired and hungry (Fabre assumed), they were moving less regularly. They finally veered from the main trail onto the silk trail left by the five wanderers four days earlier, and then continued to the ground and to their nest.

Two nearly inflexible unlearned behaviors are involved in Fabre's story. One is the following of the silk trail. The second is the tendency, shared by most crawling **herbivorous** insects, to climb the first vertical support encountered, whether it is a food plant, a fence post, or a house; this behavior makes adaptive sense because plants grow up and normally food would be up off the ground. The genetic program of the pine caterpillars includes both behaviors. Sometime in the distant past genetic changes occurred that led to these behaviors. In each case the behavior had survival value for the individual in which it occurred and for that individual's offspring, and the new genetic information spread throughout the species.

Evidence for the Evolution of Behavior

Unfortunately, behaviors are not preserved in the fossil record, which has provided so much evidence for evolution. The comparative anatomist is in an enviable position, having available for comparison the anatomical similarities and differences among living species as well as previously existing organisms that have been preserved as fossils. Comparative **embryologists** are also in a much better position than behavioral scientists, in that they can look at similarities and differences that occur as embryos develop, and detect evolutionary relationships. For example, human embryos develop gill slits (or, more precisely, grooves) very similar to those found in the embryos of fish, which (along with many other similarities) suggests an evolutionary relationship (Figure 4.3).

In examining the evolution of behavior we are limited to comparisons among species now living, and are denied any insights that a look into the past might offer. However, it is not as though we were without any guidelines at all. If evolution affects physical characteristics

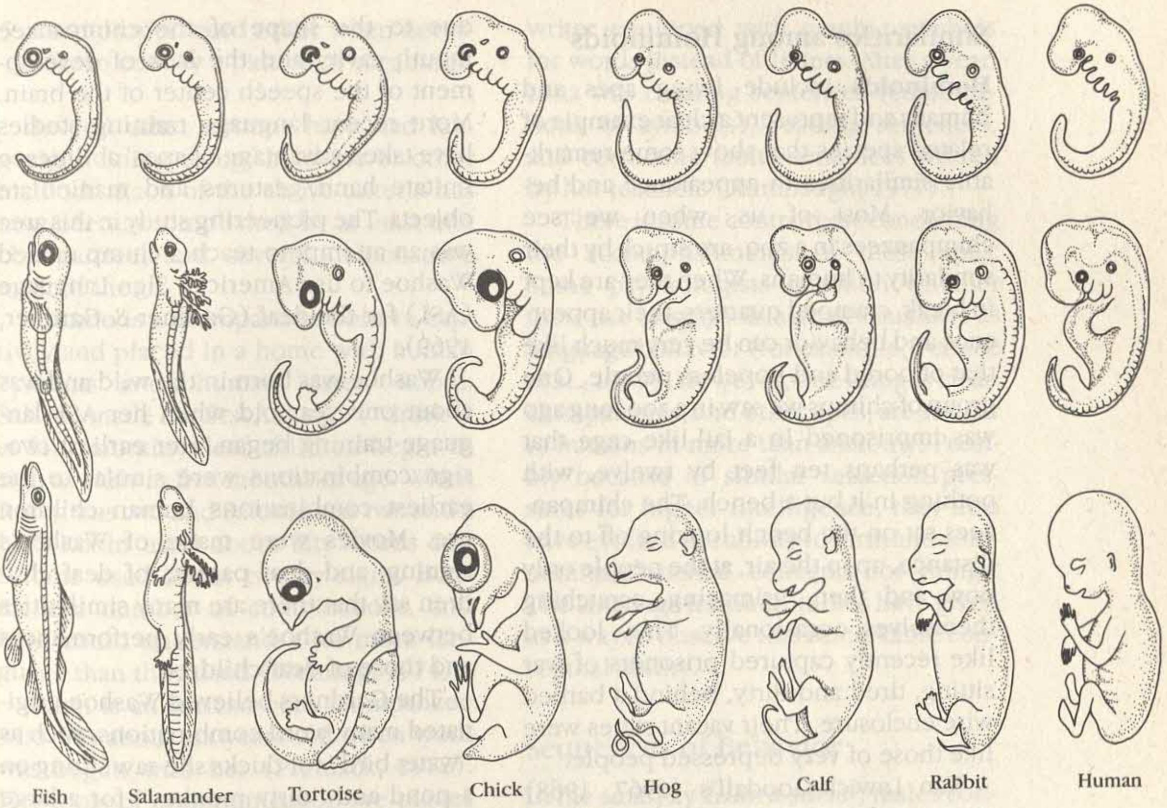


FIGURE 4.3 Stages of embryo development in various vertebrates. The similarities among the first stages shown are striking. Differentiation is apparent among the second stages shown.

it should also affect behavioral characteristics, and if behaviors do evolve we should be able to make certain predictions.

One prediction is that if animals that are believed to be closely related really do have ancestors in common, then we should see similar behaviors displayed by the species of a group. For example, certain similarities in behavior would be expected among different species of gulls, among different species of apes, and so on. Another prediction is that if behaviors evolve we should see *differences* among closely related species, in two ways: (1) We should find instances in which there are *sequences* or *progressions* in behavior, varying from species to species but accomplishing the same end for each. (2) If the species being compared live under different ecological conditions, we should find differences in their behavior that are related to the different environmental conditions. A final prediction can be made about more distantly related species: they should show similar behaviors in similar environments.

We will consider evidence bearing on these predictions in the next three parts of this section. The first prediction concerns similarities among species that are believed to be closely related.

Similarities among Hominoids

Hominoids include living apes and humans and represent a clear example of related species that show some remarkable similarities in appearance and behavior. Most of us, when we see chimpanzees in a zoo, are struck by their similarity to humans. When they are kept in bleak, cramped quarters, their appearance and behavior can be very much like that of bored and hopeless people. One group of chimps we saw in a zoo long ago was imprisoned in a jail-like cage that was perhaps ten feet by twelve, with nothing in it but a bench. The chimpanzees sat on the bench looking off to the distance, up in the air, at the people only now and then, grimacing, scratching themselves occasionally. They looked like recently captured prisoners of war sitting, tired and dirty, behind a barbed wire enclosure. Their vacant stares were like those of very depressed people.

Van Lawick-Goodall's (1967, 1968) reports of her experiences with wild chimpanzees in Africa also point to similarities between apes and humans, in happier circumstances. The gestures and much of the other behavior of the chimpanzees she studied are much like those of humans.

Some of the most detailed and fascinating accounts of ape-human behavioral similarities have come from attempts to teach language to chimps and other apes. For example, Hayes and Hayes (1951) took a baby chimpanzee, Viki, into their home and raised her like a human child until she was six and a half. At age three she was much like a human child in her use of gestures and comprehension of human language, but later she appeared to lose interest. They had little success in teaching her to talk (she learned at most four words), probably due to the shape of the chimpanzee mouth cavity and the lack of development of the speech center of the brain. More recent language training studies have taken advantage of apes' abilities to imitate hand gestures and manipulate objects. The pioneering study in this area was an attempt to teach a chimp named Washoe to use American Sign Language (ASL) for the deaf (Gardner & Gardner, 1969).

Washoe was born in the wild and was about one year old when her ASL language training began. Her earliest two-sign combinations were similar to the earliest combinations human children use. Movies were made of Washoe's signing, and deaf parents of deaf children say that there are many similarities between Washoe's early performances and those of deaf children.

The Gardners believed Washoe originated many word combinations, such as "water bird" for ducks she saw sitting on a pond and "dirty monkey" for a large monkey that had threatened her. Previously she had used "monkey" properly, but "dirty" had been used only for soiled objects or for feces. Later she signed "dirty" at her teachers when they displeased her. There is, however, some controversy about how novel these usages and combinations actually were.

Certain psychologists were not impressed with the early performances of Washoe, and felt her accomplishments would not be of scientific importance until she:

1. had an extensive system of names for objects
2. signed for objects not present
3. used signs for concepts, in addition to objects and actions
4. invented semantically appropriate combinations

5. used proper word order when necessary to convey a particular meaning.

Several other chimps have had language training using the same or other methods. Each of the above criteria has now been accomplished by at least one chimpanzee, and several demonstrate most of them.

Salome is a chimpanzee born in captivity and placed in a home with human "parents" and a human "sister," Robin. Salome made her first ASL sign ("drink") at four months; deaf children begin to sign as early as five months of age. When Robin was two and Salome was two and a half, Robin used about fifty words and Salome used about twenty signs. Both made a number of combinations, and both could understand a lot more language than they used (Fleming, 1974).

Sarah is an African-born chimpanzee who was about six years old when work was begun with her (Premack, 1972). Her tools of communication are pieces of plastic of various shapes and colors. Each plastic piece represents a word. In spite of her relatively advanced age, Sarah demonstrated an impressive array of conceptual and communicative abilities. After two and a half years she was using the symbols correctly and making proper combinations of symbols to communicate her intentions. In addition, she was using class concepts, the conditional, conjunctions, copulas, interrogatives, negation, pluralization, and quantifiers. These are very impressive accomplishments in communication, especially when we consider that Sarah lived in a wire cage indoors and that both her language training and her contact with humans were limited to one hour a day five days a week.

A fourth chimpanzee, Lana, was two when she began learning to use a typewriter equipped with graphic symbols for words instead of letters. After a year, Lana was creating sentences (combinations of symbols), reading sentences, and correcting faulty sentences written by her teachers (Rumbaugh, 1977).

There is some controversy concerning the accomplishments of these apes. Some psychologists question whether their use of symbols actually qualifies as language behavior (for example, Terrace et al., 1979). However, one thing is clear: chimpanzees, and other apes, are similar to humans in more than anatomy. Possibly because of similar selection pressures for higher intelligence, they also have evolved the ability to form and communicate mental concepts for things. The language training studies have given us a way to observe this remarkable conceptual ability.

Sequences of Behavior

In the small fly *Hilara sartor,* males congregate in courtship swarms, each male carrying a hollow balloon of silk. When a female arrives she selects a male, takes his silk balloon, and they fly away and mate (Figure 4.4). What strange behavior! What does the silk balloon have to do with bringing a female fly to mating readiness?

Kessell (1955) made extensive studies of the group to which *H. sartor* belongs, and has shown that there are eight types of courtship behavior among the various species. The first six types are found in carnivorous species, those that eat other small flies, including members of their own species. Males of some of these species will simply court a female in isolation. Males of other species capture a prey (another small fly) first, and then court a female in isolation; she accepts the food and consumes it during

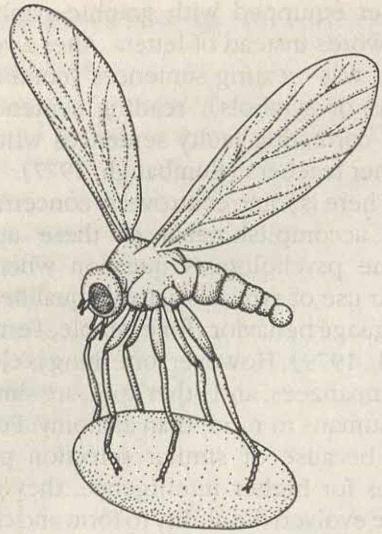


FIGURE 4.4 *Hilara* male with silk balloon.

mating. In a third group of species the males capture prey and then form swarms, as do males of the remainder of the types; females come to the swarm, select mates, take the prey, and then mating occurs. In the fourth type males apply a few strands of silk to the prey. In the fifth type the males completely wrap the prey in silk. So far the female has been receiving food from the male, but in the sixth type the male removes the food content of the prey before wrapping it in silk and the female receives only a token — an empty husk wrapped in silk.

The two remaining types of courtship behavior are found in species that feed on nectar. In the seventh type a male finds a dried fragment of an insect on the ground and constructs a large silk balloon with the fragment inside, which he offers to the female. And finally we come to the eighth type, to which *H. sartor* belongs, which merely constructs a balloon for presentation to the female.

Thus we can see the stages that may have been involved in the evolution of the strange courtship behavior of *H. sartor.* If the behavior of the other species had not been discovered, or if the other species had become extinct before they could be studied, the silk balloon aspect of *H. sartor* mating behavior would have remained as much a mystery as it was when it was first discovered.

Differences among Gulls

A majority of gull species nest on the ground near water—in sand dunes, marshes, or other relatively flat situations. The small gulls called kittiwakes, however, nest on narrow ledges on steep cliffs. As we would expect from their similar genetic backgrounds, gulls in general, including kittiwakes, have a number of behaviors that are very similar—foraging behavior, for example. But while breeding behavior (mating, nesting, rearing young) is similar among the ground-nesting species, in many aspects it is strikingly different for kittiwakes. The variations are largely due to the different locations of the nests, and the consequent differences in selective pressures. For example, ground-nesting gulls are bothered by a number of different predators, but kittiwakes are not. Steep cliffs are relatively free of predators because they are difficult and dangerous for nonflying predators to climb, and flying predators have difficulty maneuvering because of wind currents and the small size of the ledges. On the other hand, kittiwake nesting sites are much more cramped, and the egg or chick that gets out of the nest risks a long fall to the rocks or water below, a problem not faced by ground-nesting gulls.

Over two dozen differences in behavior have been noted between ground-

A herring gull, one of the ground-nesting gulls.

nesting gulls and kittiwakes, most of them associated with the differences in their nesting sites. Table 4.1 shows a few of these behavior differences.

The last of the predictions we outlined earlier was that relatively unrelated species living in similar habitats should show similar behaviors. This prediction is supported by studies of cliff-nesting gannets. These sea birds have been shown to display many of the same behavior patterns that differentiate kittiwakes from ground-nesting gulls.

Coevolution of Characteristics

Improvements in one characteristic of a species may provide selective value for improvements in another characteristic, changes that would not have been of value before. We will look at sea otter feeding behavior as a hypothetical example.

A sea otter obtains its food by breaking open mollusk and sea urchin shells while floating on its back in the water. The otter holds the food item in one paw and strikes it against a rock placed on its chest, or places the food item on the rock and hits it with another rock. However, sea otters are limited to feeding on items that they can pull off rocks or other substrate using their paws. Suppose a sea otter's brain could imagine using a rock shaped something like a stone spearhead to pry oysters loose. Rocks of that shape are hard to find, though, and even if the sea otter could imagine making one by chipping with a larger rock, it lacks sufficient dexterity to do so. Now if the otter's brain did in fact evolve enough to be able to imagine such tool-making, there would be obvious selective value for improvement of its digits so that they were longer and better able to manipulate. If genetic changes occurred through many generations, to cause them to be that way, the brain and the digits could work together more efficiently. Once the sea otter had hands that could manipulate

TABLE 4.1 Some Differences in Behavior Between Ground-Nesting Gulls and Kittiwakes

Gulls	*Kittiwakes*
1. The nest is a small pile of grasses. (If eggs get out of the nest they can be retrieved.)	1. The nest is a substantial mud cup lined with grasses. (If eggs get out of the nest they are likely to be lost.)
2. Nest material is not stolen from other nesting pairs. (Nest material is plentiful around the nesting site.)	2. Nest material is often stolen from neighbors. (Trips must be made to gather nesting material.)
3. Droppings and eggshells are carried away from the nest. (Their presence at the nest attracts predators.)	3. Egg shells and droppings are left around the nest. (There are no predators.)
4. Parents learn to recognize their young very early. (Young often wander out of the nest.)	4. Parents learn to recognize their young much later. (Young can't wander, and are recognized by location.)
5. Parents often regurgitate food for nestlings onto the ground.	5. Young always take food directly from parents.

things better, there would be selective value for a more improved brain, capable of imagining even more complicated projects. Then still better hands would be of value, and so on.

We can speculate that these are the sorts of pressures and changes that operated during the development of the human hand and brain. Changes in one reinforced changes in the other, and made further improvements adaptive.

This sort of coevolution is also probably what happened during the evolution of human speech. Once the internal shape of the mouth began to enlarge, starting in *Ramapithecus* (see Supplement 4), it was possible to make a greater variety of vocal utterances. This would provide high selective value for any mutations that made it possible for the brain to "think of more things to say," and to develop vocal signals for more ideas or activities. Or suppose that the brain already was thinking of more things to say, but that the equipment was limiting; there would then be selective value for mutations that improved the shape of the mouth and the dexterity of the tongue. In either case, communication would be improved and survival enhanced.

That behavior can affect the evolution of structure is a major point in Jean Piaget's *Behavior and Evolution* (1978). Piaget, originally a biologist, continued to make substantial contributions to that field through the years, although he is best known for his outstanding contributions to psychology and to education. In *Behavior and Evolution* he again makes a valuable contribution, this time arguing the importance of behavior in effecting evolutionary change. This idea is not new, but it has received little attention from biologists. In fact, in the last fifteen years the only other book on the biology of evolution to discuss the topic at all is Mayr's *Populations, Species, and Evolution* (1970), in which he devotes about three pages to the subject.

Piaget emphasizes that what an organism does, or does not do, has as much of a role in shaping the process of natural selection as does the environment. He writes:

> Here again it is worth quoting Monod, when he maintains so correctly that the selective theory has "been too often understood or represented as placing the sole responsibility for selection upon conditions of the external environment. This is a completely mistaken conception. For the selective pressures . . . are in no case unconnected with the . . . performances characteristic of the species. . . . [It is] specific interactions, which the organism itself 'elects,' at least in part, [that] determine the nature and orientation of the selective pressure the organism sustains" (pp. 155–56).

The brief introduction to evolutionary ideas presented in this chapter is intended to provide a basis for thinking about the adaptive significance of behavior. The idea of evolution by natural selection is the greatest unifying theory in the biological sciences. Looking at the adaptive significance of structures, functions, and behaviors has given us a clearer and more unified view of why organisms are the way they are.

Supplement 1. What Is a Species?

A **species** is a group of actually or potentially interbreeding individuals that do not breed with members of other such groups under natural conditions. This definition is necessarily vague; and we will examine its parts and then see why.

1. *A species is a group of . . . interbreeding individuals.* This does not refer to multiple or promiscuous matings. It means that the genes carried by one individual are available to be mixed with the genes of any other individual of the species through their mating or the mating of their children or grandchildren. *Actually interbreeding* means that the members of a species that live near each other do interbreed. *Potentially interbreeding* allows for the fact that members of the same species living in different geographic areas could interbreed if they were together; for example, house sparrows (English sparrows) living in Pennsylvania could interbreed with those living in Wyoming.

2. *. . . do not breed with members of other such groups.* This means simply that robins mate with robins but not with blue jays. Blue jays mate with others of their species (other blue jays) but not with robins or even with Steller jays or Canada jays. And of course none of the above mate with gulls or squirrels, much less jellyfish or roses or oak trees.

3. *. . . under natural conditions.* This qualification covers instances in which members of different but very similar species will interbreed under abnormal conditions, usually conditions imposed by humans, such as in laboratories or zoos. Of course elephants would not and could not mate with donkeys under any circumstances. However, occasionally individuals of two similar species that have no interest in each other in nature — in many cases because of differences in courtship behavior — will interbreed in captivity when confined together and away from other members of their own species. A familiar example of this is the breeding of horses with donkeys, which produces mules. In the wild, horses run in herds and so do donkeys; they would not normally be together at breeding time.

Each species is unique, and can be distinguished from all other species by certain external physical characteristics. As more knowledge accumulates we are finding that each species can also be defined by its physiological and behavioral characteristics as well. In fact, the easiest way to distinguish some animal species is by looking at their behavior, and such observations have often resulted in the discovery that what had been regarded as one species actually included two or more species.

Supplement 2. The Population Concept

In evolution and ecology the term *population* is used somewhat differently than it is when we talk about human populations. A population in ecological and evolutionary usage can be defined as all the members of a species in a given area. The "given area" in the definition is flexible, and generally varies with the size and mobility of the animal species being discussed. It would be appropriate to study the population of a species of snails in a small area such as a backyard. If a population of deer were under scrutiny, the study area would probably include several square miles.

Regardless of area size, when we speak of a population in this book—including prehuman and human populations—we will be speaking of the members of one species in one area. In evolutionary and ecological discussions reference to the population of butterflies in an area would ordinarily be meaningless, since there are almost certainly several species of butterflies there. We would be correct, however, if we spoke of the population of monarch butterflies, or the population of mourning cloak butterflies, in a particular locality.

It is within the population that breeding occurs, and from among members of the population that natural selection selects. Occasionally a population may be confronted with very adverse conditions—disease or drought, for example—and only the hardiest or most cunning survive. Or conditions may be so bad that the population becomes extinct. Normally if local extinction occurs, members of neighboring populations of the same species will come to occupy the vacated habitat and utilize its resources, but if the disaster is very widespread the entire species may become extinct.

Supplement 3. Speciation

In our discussion thus far of how natural selection works on populations through time, the focus has been on single populations or at least populations under one set of environmental conditions. However, genetic changes in fact occur *randomly* in *all* populations, whether the environment is stable or changing. Due to this more or less constant variation, any population can evolve through time. Thus adaptations to the environment can be continually improved, and ultimately the population may change enough to be called a new species. If two segments of a population become geographically isolated, they may change in different ways and become distinct species.

Geographic Isolation

Suppose a few birds from an established population were flying when a storm came up, and were blown too far away to find their way home. Once the storm has ceased we would expect them to search for their original habitat and, not finding it, keep moving until they found a suitable environment. Perhaps lost birds usually perish, but now and then such an occurrence leads to the establishment of a new population in an area where there were previously no other members of that species.

Conditions in the new area must be similar enough to those in the original habitat for the immigrants to be already minimally adapted to survive and reproduce there, or they could not become established. Even so, we would expect that conditions in the new environment will be somewhat or even substantially different, and therefore that different selective pressures will exist. Since genetic variation can be expected to occur, the population may evolve gradually in response to the new conditions. In time it may become noticeably and significantly different from the population from which it came.

Suppose that after a few thousand years the original and the relocated populations of the birds discussed earlier expanded their areas of distribution so that the areas overlap. What will happen? Will two groups interbreed? Can they interbreed?

We will return to these questions after we have taken a look at isolating mechanisms.

Isolating Mechanisms

The factors that interfere with the successful interbreeding of different species when they are together are called **isolating mechanisms.** Obviously geographic isolation is not an isolating mechanism, because it does not fit the definition. However, geographic isolation is ordinarily necessary before isolating mechanisms can develop, because it prevents the exchange of genes between the populations and thus allows differences to accumulate.

The factors that can serve to keep different species from interbreeding when they are together can be divided into two groups, premating isolating mechanisms and postmating isolating mechanisms. Either kind can serve to keep species biologically separate.

Premating Isolating Mechanisms Factors that tend to keep members of different species from mating with each other include temporal, ecological, behavioral, and mechanical isolation.

1. Temporal isolation: the species occur in the same habitat but appear or breed at different times of day or in different seasons.
2. Ecological isolation: the species occur in the same general area but breed in different places, such as in woods versus clearings.
3. Behavioral isolation: courtship behaviors of the two species are sufficiently different so that at least one member (usually the female) is not stimulated, or courtship breaks down before mating occurs.
4. Mechanical isolation: Copulatory parts do not fit.

Postmating Isolating Mechanisms The major factor that prevents or tends to prevent the production of offspring *after* mating has occurred is **genetic isolation,** resulting from total or partial genetic incompatibility. Sperm and egg do not unite, or union occurs but development does not occur, or development begins but is not completed, breaking down sometime before sexual maturity is reached, or offspring are sterile or at least reproduce much less successfully than normal.

Overlap after Geographic Isolation

Now we will return to the two groups of birds we were discussing earlier. A part of the original population had been blown to a new area during a storm, undergone

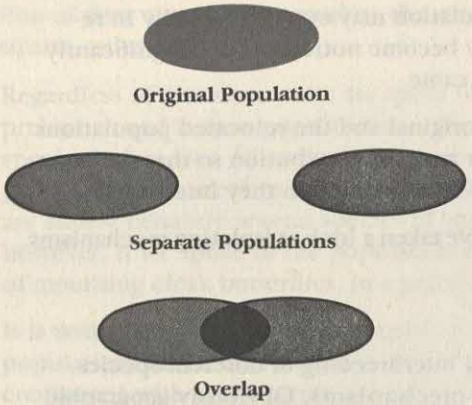


FIGURE 4.5 A population breaks into subdivisions, which may later overlap.

some change, and after a few thousand years the "new" and "original" populations came to overlap in their distribution as illustrated in Figure 4.5. What will happen? Will they interbreed? Can they interbreed?

What happens depends on how different the two groups have become. The original population may have changed also; if it has, the changes are probably different from those in the relocated population.

One of four things may happen when members of the two populations come into contact:

1. They may interbreed freely and successfully, each assimilating variations present in the other. Speciation has not occurred; isolating mechanisms have not developed.

2. They may not interbreed at all. Speciation has occurred; isolating mechanisms have developed.

3. Mating may be attempted without reproduction being accomplished. Speciation has occurred; isolating mechanisms have developed.

4. Some members of each group may interbreed with members of the other group but produce no offspring, or produce offspring of reduced viability. Speciation has begun, but isolating mechanisms are incomplete. In this case we would expect that in time the partially developed isolating mechanisms would be reinforced by the reduced reproductive success of the interbreeders. Those that bred with their own kind would produce more, and more vigorous, offspring.

Probably most often it is behavioral differences, especially differences in courtship behavior, that are the primary isolating mechanisms in such cases as that of the relocated birds. But whichever mechanism is the effective one, one species can evolve into two, if it becomes divided and the two groups do not exchange genetic material.

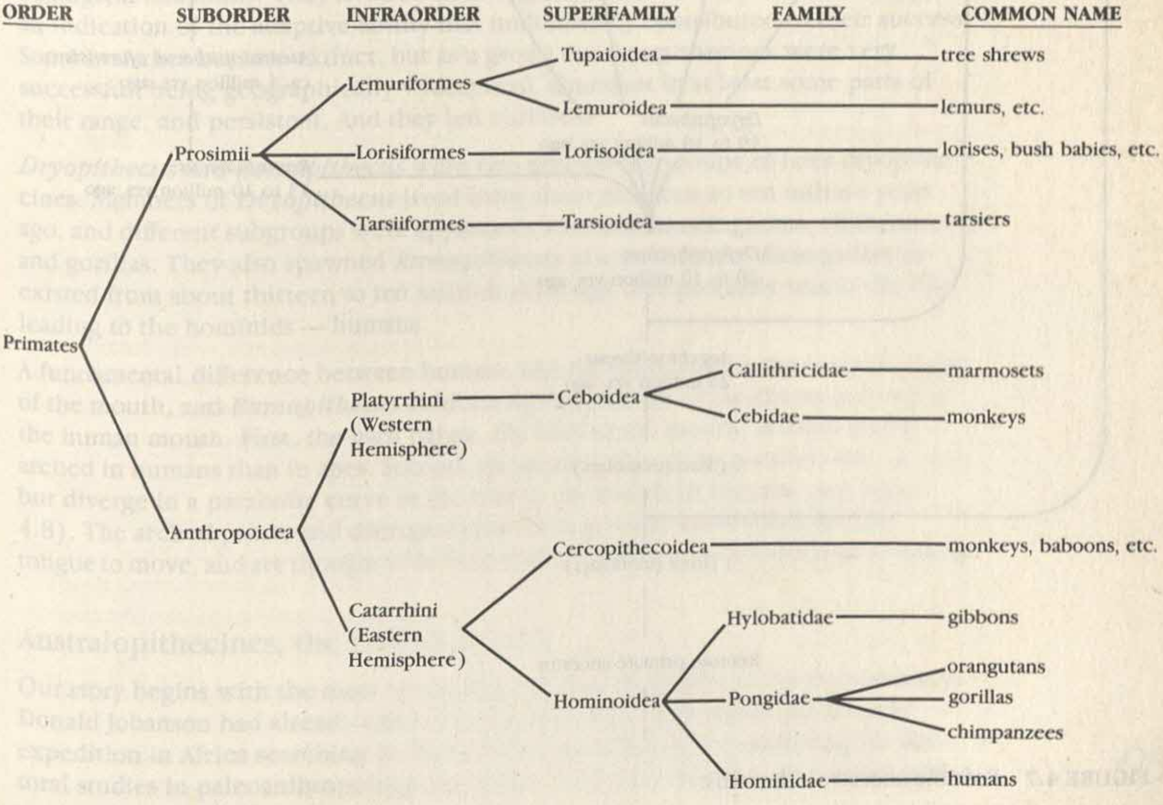
Supplement 4. The Evolution of Humans

It is obvious even to the casual observer that humans have many characteristics in common with apes and monkeys. No informed person would seriously argue that humans evolved from any species of apes or monkeys now living, nor did Darwin say that. However, it is becoming increasingly clear from fossil discoveries, which we will outline below, that humans and the apes had ancestors in common.

The *exact* evolutionary history of humans is not known, and what is known is rather complex and laced with tongue-twisting scientific names. What follows is a simplified outline.

Humans are classified in the animal phylum Chordata, class Mammalia, order Primates, suborder Anthropoidea (monkeys and apes), superfamily Hominoidea (apes), family Hominidae (Figure 4.6). The primates had become a line separate from the other mammals by about seventy-five million years ago, and the anthropoids made their appearance about thirty-five million years later.

FIGURE 4.6 Brief classification of living primates.



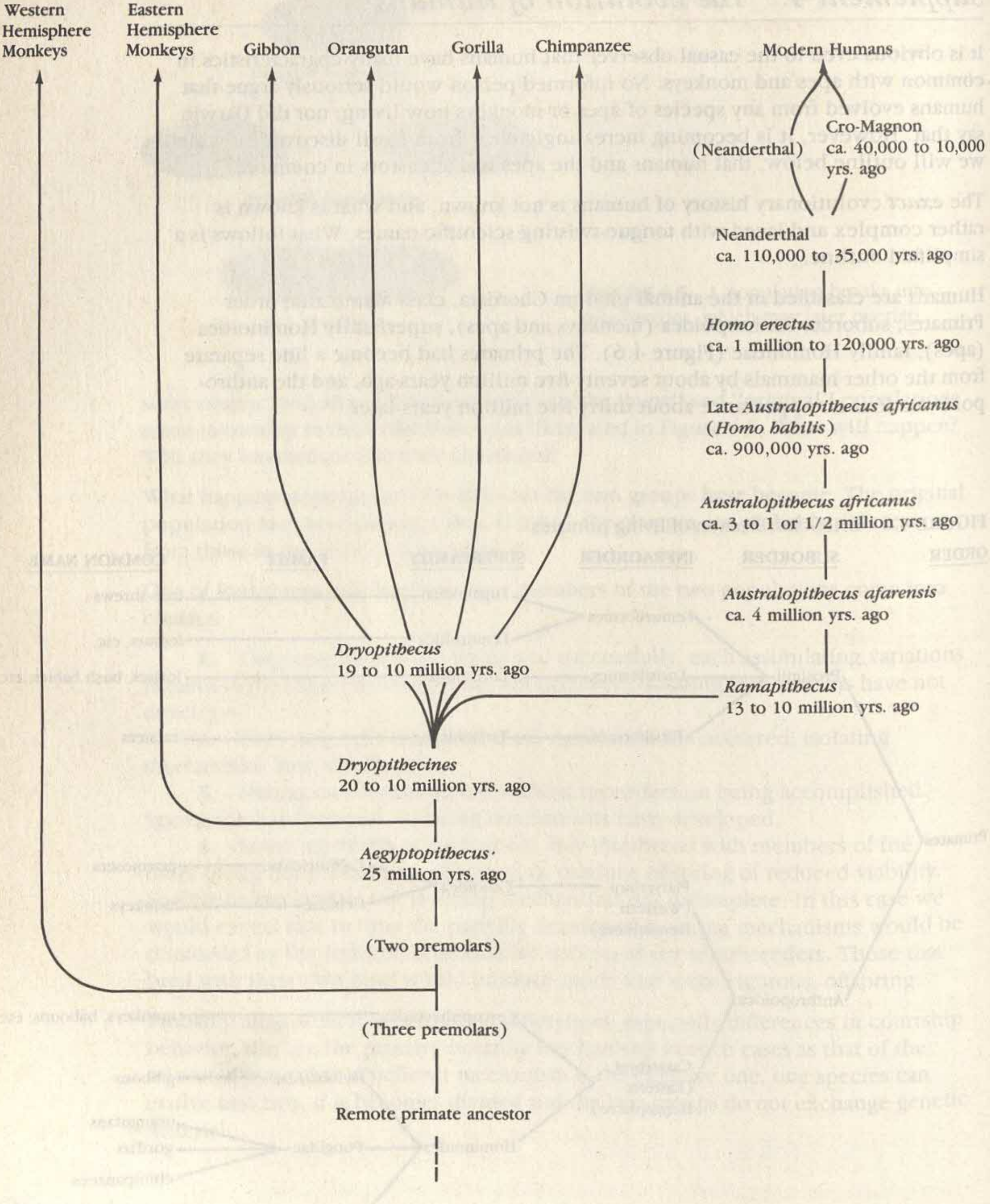

Western Hemisphere Monkeys
Eastern Hemisphere Monkeys
Gibbon
Orangutan
Gorilla
Chimpanzee
Modern Humans
(Neanderthal)
Cro-Magnon
ca. 40,000 to 10,000 yrs. ago
Neanderthal
ca. 110,000 to 35,000 yrs. ago
Homo erectus
ca. 1 million to 120,000 yrs. ago
Late *Australopithecus africanus*
(*Homo habilis*)
ca. 900,000 yrs. ago
Australopithecus africanus
ca. 3 to 1 or 1/2 million yrs. ago
Australopithecus afarensis
ca. 4 million yrs. ago
Dryopithecus
19 to 10 million yrs. ago
Ramapithecus
13 to 10 million yrs. ago
Dryopithecines
20 to 10 million yrs. ago
Aegyptopithecus
25 million yrs. ago
(Two premolars)
(Three premolars)
Remote primate ancestor

FIGURE 4.7 Possible ancestry of humans.

A fundamental anatomical difference among anthropoids that is useful with fossils and therefore helpful with our story is the number of premolar teeth. Western Hemisphere monkeys have three premolars on each side, upper and lower, while Eastern Hemisphere monkeys and the apes have only two.

As Figure 4.7 indicates, the evolutionary line leading to the Western Hemisphere monkeys separated early, prior to twenty-five million years ago, when *Aegyptopithecus* existed. *Aegyptopithecus* was about the size of a small monkey, and is the oldest fossil known with only two premolars. But the oldest group of anthropoids that we have much information about is the dryopithecine apes.

The Dryopithecines, or Oak Apes

The dryopithecines were a large and diverse group of early apes that were apparently ancestral to humans and the other living apes and to a number of other groups now long extinct. The several types of dryopithecines lived between twenty and ten million years ago, and were spread across Europe through Turkey and into China, and in parts of east Africa.

Here we see a record of a very successful group of early apes that evolved through time to produce populations capable of inhabiting and reproducing in a variety of ecological situations. They lived in forests, grasslands, and intermediate habitats, an indication of the adaptive ability that undoubtedly contributed to their success. Some branches became extinct, but as a group the dryopithecines were very successful, being geographically widespread, abundant in at least some parts of their range, and persistent. And they left survivors.

Dryopithecus and *Ramapithecus* were two noteworthy groups of later dryopithecines. Members of *Dryopithecus* lived from about nineteen to ten million years ago, and different subgroups were apparently ancestral to orangutans, chimpanzees, and gorillas. They also spawned *Ramapithecus* as a sidebranch. *Ramapithecus* existed from about thirteen to ten million years ago, and probably was in the line leading to the hominids — humans.

A fundamental difference between humans and the other apes is the internal shape of the mouth, and *Ramapithecus* exhibits the beginnings of the characteristics of the human mouth. First, the hard palate, the roof of the mouth, is more highly arched in humans than in apes. Second, the molar teeth are in parallel rows in apes, but diverge in a parabolic curve in the rear of the mouth in humans (see Figure 4.8). The arched palate and divergent rear teeth provide more space for the tongue to move, and are thought to be important in the eventual production of speech.

Australopithecines, the First Hominids

Our story begins with the most recent discovery in the search for human ancestry. Donald Johanson had already spent two seasons with a joint American-French expedition in Africa searching for hominid fossils while still completing his doctoral studies in paleoanthropology. At a party in Paris he became acquainted with a

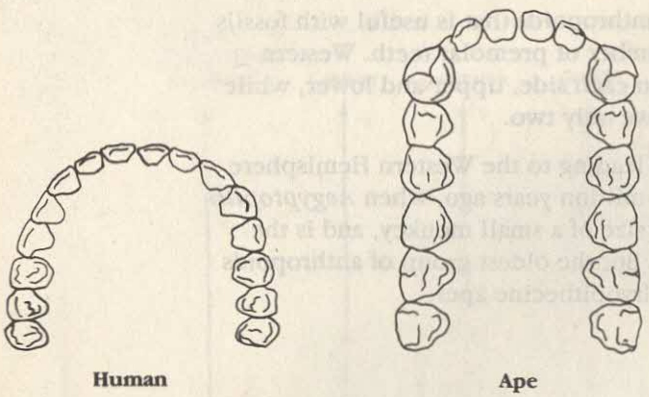


FIGURE 4.8 Human and ape tooth arrangements. The molar rows of humans diverge toward the back of the mouth, while the molar rows of apes are parallel.

young geologist named Maurice Taieb, who was working in the Afar area of Ethiopia in eastern Africa, near where the Red Sea and the Gulf of Aden meet. Taieb told Johanson of a huge eroded area at Afar where fossils were lying all over the place. At Taieb's urging, Johanson went with him to Afar and was almost immediately convinced that the area showed great promise, far greater than the area he had been working previously.

Johanson finished his doctoral studies and organized an expedition to work in the Afar triangle. In his first season there, 1973, he discovered a fossil knee joint that he at first thought belonged to a monkey, it was so small. But the knee joint was more like a human's than a monkey's, and this caused considerable excitement. The following year Johanson found several bone and skull parts exposed on the surface of the ground, and after three weeks of excavating the crew had assembled about 40 percent of a skeleton of an early hominid about three and a half feet tall. (Beginning with the australopithecines, all fossils on or close to the line leading to humans are assigned to the family Hominidae and are commonly called hominids.)

It is standard practice to give names to fossils in the field—not scientific names, but names such as George or Cindy, for handy use in discussion. It was clear from the shape of the pelvis that this fossil was a female, and she was named Lucy, after the Beatles' song "Lucy in the Sky with Diamonds," which was playing on the camp tape machine when the skeleton was assembled.

The following year several more remains similar to Lucy were discovered, and were nicknamed "The First Family." After extensive study of Lucy, The First Family, and some similar but more fragmentary fossils found by Mary Leakey about five hundred miles south, Johanson named them *Australopithecus afarensis,* after the Afar region of Ethiopia where they were discovered.

There are five features of Lucy's skeleton that are particularly striking. One is that it is so small, the smallest hominid known. Another is that it is almost four million years old, more than a million years older than the next oldest hominid fossil. Third, it is relatively complete; the oldest skeleton that is more complete is a seventy-five-thousand-year-old Neanderthal. Fourth, the shape of the pelvis and the knee joint of Lucy and The First Family provide convincing evidence that these hominids walked upright. And fifth, the head is small relative to the rest of the skeleton, only a little larger than a softball. For many years it was believed that erect posture and the great expansion in brain size leading to the large human brain had evolved together along with the use of the hands for carrying and manipulating objects. These fossils show that walking upright evolved first; the hands were thus freed from locomotor function when the brain was only 380 to 450 cubic centimeters, averaging slightly larger than a chimpanzee's.

Prior to Johanson's discovery of *A. afarensis,* the oldest known fossil hominids were *A. africanus*. In 1924 a friend brought Raymond Dart some fossil-bearing rocks from a quarry at Taung, Bechuanaland, in southern Africa. Two of these fitted together perfectly. One showed a rather large cranial cast, the other a piece of jawbone. Carefully Dart chipped away the rock to expose the fossils. After seventy-three days of painstaking work he had exposed a nearly complete skull.

What Dart had found was a juvenile, perhaps five years old, judging from the condition of the teeth—but a juvenile what? The brain size corresponded roughly to that of an adult chimpanzee. But even a young chimpanzee would have prominent brow ridges, and the fossil did not. And then there were the unchimplike characteristics of the teeth. The incisors and canines, especially, were much more like those of humans, and the teeth formed a parabolic arch. Because of these and other characteristics, Dart recognized that his discovery was much closer to humans than to any other known ape, either fossil or living.

Dart named his discovery *Australopithecus africanus*. During the 1930s and '40s many other fragments, skulls, teeth, and most other parts of the adult body skeleton were found by Dart and others, and since then still more have been found.

A. africanus stood nearly four feet tall and had brain sizes of 430 to 550 cubic centimeters. The oldest remains are nearly three million years old, and the most recent about two million. Stone tools have been found that are also up to three million years old, but none are definitely associated with *africanus* remains. Although Johanson disagrees, many researchers believe *africanus* was a tool-maker. If he wasn't, the maker of those tools is yet to be discovered.

Dart found evidence that convinced him *africanus* used tools. In the same deposits as the *africanus* fossil remains he found the smashed bones of rodents, shrews, birds, turtles, small antelope, and even baboons. Most striking are the fossil baboon skulls. About 80 percent show marks indicating they received a blow to the head. Because these marks are quite localized, it appears the baboons may have been struck with a weapon, rather than killed by something like falling rocks. Moreover, many of the skulls show a side-by-side pair of indentations, suggesting a double-headed weapon.

Dart searched the fossil-bearing rocks for objects that might have caused the damage. Among the numerous bones he examined were many upper front leg bones (humerus) from antelope. Almost every humerus showed indications that the double end was chipped or otherwise damaged before fossilization. Apparently some creature had killed the baboons with bone clubs.

There was also evidence suggesting differences in tradition or culture among the club-wielding creatures. At Taung and Makapansgat a majority of the baboon victims were adults. At Sterkfontein most were infants; the few adult baboon skulls there were rather badly mauled, showing several club marks rather than the usual single one.

A few of the skulls show injury on the rear, suggesting attack from behind. However, most were injured on the face, and the great majority on the left side of the face. Was the attacker right-handed? Dart believed it was *A. africanus* who wielded the clubs.

Before *afarensis* was found, *africanus* was generally believed to be a human ancestor. Johanson believes *africanus's* teeth are out of line with those of *afarensis* and later hominids believed to be ancestral to humans, and therefore that *africanus* represents a side branch ending with the larger but primitive *Australopithecus robustus.*

One problem with assigning *africanus* to a side branch is that doing so would leave a gap of over a million years between *afarensis* and the next hominid generally accepted, even by Johanson, as being in the main line of human evolution. And this hominid is thought by many to be no more than an advanced, later form of *A. africanus,* although others have called it *Homo habilis.*

Louis Leakey found *Homo habilis* in 1962 in the Olduvai Gorge in Tanzania, which is near the place Mary Leakey found her fragments of *A. afarensis* years later. Many additional specimens have been found since, several of them definitely associated with stone tools. *H. habilis* approached four and a half feet in height; brain size varied from 460 to 800 cubic centimeters. Specimens are between one and two million years old. Richard Leakey's KNM-ER 1470 skull belongs to this species, and is now known to be 1.8 million years old, rather than the 2.6 million originally reported.

The Genus Homo

A few workers have included all *A. africanus* specimens in the genus *Homo,* but most feel *africanus* is too primitive to be considered fully human. Whether *H. habilis,* also known as late *A. africanus,* belongs here depends on one's point of view.

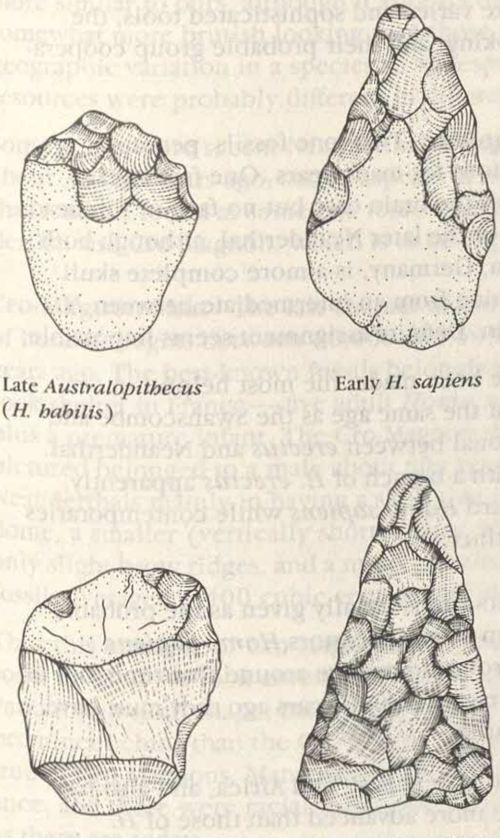
The first undisputed member of the genus *Homo* to appear in the fossil record is *Homo erectus.* In 1894 Eugene Dubois announced that he had discovered in Java the "missing link" — fossils of an animal intermediate between man and the other apes. Controversy raged, as with most new discoveries and ideas (and some that are not so new). But later discoveries filled out the picture of this "erect ape man," as Dubois called it, and the controversy died. We now recognize that it is much closer to humans than to other apes.

Dubois's Java finds are about 550,000 years old. Later, additional specimens about 350,000 years old were found in China, along with convincing evidence that they used fire. The oldest known specimen of *H. erectus,* Olduvai hominid 9, is from east Africa, and may be as much as one million or even one and a half million years old.

Physically *H. erectus* is very interesting, because the body skeleton is within the range of variation for *Homo sapiens* but the skull is much more primitive. The face is larger, the brow ridges much heavier, the forehead very low, and the teeth more or less intermediate between *H. habilis* and *H. sapiens.*

Brain size of the Java specimens averaged about 930 cubic centimeters, while those from China averaged about 1,040. Of course the China specimens are about 200,000 years younger, which could mean they had evolved further; or the difference could be simply racial, due to geographic variation. Brain sizes of *erectus* ranged from 750 to 1,250 cubic centimeters, overlapping both *H. habilis* and modern man. Height ranged from four and a half to six feet.

The tools of *H. erectus* are often somewhat different in different localities, but in general include some like those used by *H. habilis* and others that are more sophisticated (Figure 4.9). Many of the stones *H. erectus* selected for tool-making



Late *Australopithecus* (*H. habilis*)

Early *H. sapiens*

H. erectus

Recent *H. sapiens*

FIGURE 4.9 Examples of stone tools at various stages in the evolution of humans, indicating their increasing sophistication from earlier to later stages.

were types that would flake more predictably than most of those used by *H. habilis,* and therefore could be shaped with more precision. There are awl-like tools that may have been used for working leather, and tools that appear to be picks and could have been used to dig for roots and insects. There are animal bones that have been sharpened on one end. Hand axes are often found with the bones of rhinos, elephants, horses, and deer, suggesting the axes were used in butchering.

The emergence of new kinds of tools suggests creativity. The presence of hand axes among the bones of large animals suggests that *H. erectus* hunted these animals. Killing large animals probably required hunting in groups, which requires communication and cooperation. Also, shelters were built in at least one locality, and they are sufficiently large to suggest group living. Fire was probably used by *H. erectus* for cooking as well as for warmth. In China hearths were found with thick layers of ash, and in the ash are great quantities of burned bones from small and large animals, and some from humans of all ages and both sexes.

H. erectus was a very successful group. They were numerous in at least some areas, and were geographically widespread, having been found in Europe, Israel, east and north Africa, China, and Java. Their culture was substantially more advanced than that of *H. habilis,* as is shown by their more varied and sophisticated tools, the presence of shelters, the use of fire for cooking, and their probable group cooperation in hunting.

The Transition from *H. erectus* to *H. sapiens* Two lone fossils, perhaps 300,000 years old, have tweaked imaginations for many years. One from near Swanscombe, England, consisting of most of the brain case but no face or forehead, is impossible to assign to either *H. erectus* or the later Neanderthal, although both have been argued. Another, from Steinheim, Germany, is a more complete skull that has been variously classified as everything from an intermediate between *H. erectus* and Neanderthal to a modern human. Definite assignment seems impossible.

In the past few years other discoveries have been made, the most helpful in Tauteval, France. The fossils there, of about the same age as the Swanscombe and Steinheim finds, seem clearly to be transitional between *erectus* and Neanderthal. Again it seems that speciation occurred, with a branch of *H. erectus* apparently advancing along the evolutionary path toward *Homo sapiens* while contemporaries did not advance and ultimately became extinct.

Neanderthal Man A date of 110,000 years ago is usually given as the probable time of origin of *Homo sapiens,* in the form of our ancestors *Homo sapiens neanderthalensis.* The oldest fossils date from somewhere around that time, but of course if humans were in the Neanderthal stage 110,000 years ago they must have been nearly there several thousand years earlier.

Neanderthal was widespread over Europe, the Near East, and Africa, and also has been found in China and Java. The tools are more advanced than those of *H. erectus* and the body skeleton is nearly identical to ours. The skull is distinguish-

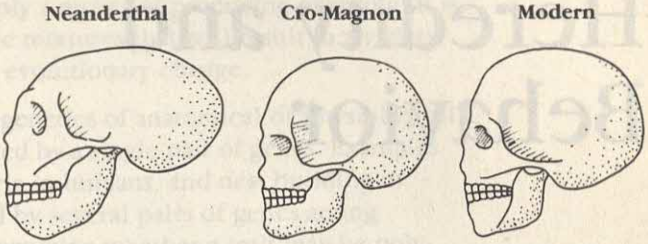


FIGURE 4.10 Skulls of humans. Note the receding forehead ("low brow") and receding chin of Neanderthal as compared with Cro-Magnon, and the slightly receding forehead and chin of an "average" modern human. There is a wide variety of skull shapes among modern humans.

able from ours, most easily by the sloping forehead and heavier brow ridges, while the sizes of the brain cavity (1,200 to 1,750 cubic centimeters) overlap the larger of the *H. erectus* measurements on the lower side and ours on the upper.

Neanderthal is usually portrayed by artists and cartoonists as a stooped, brutish character much different from ourselves. Certainly the skull shape is different, but the stooping is highly exaggerated; their body skeletons are nearly the same as ours, even in posture. The specimen that was the basis for the original drawing of Neanderthal — the source of the popular misconception — is now known to have been an old male with arthritis. Other specimens indicate an upright posture much more similar to ours, although it appears that European Neanderthals were in fact somewhat more brutish looking than those found elsewhere. We would expect geographic variation in a species so widespread, especially since climate and resources were probably different in different areas.

Some of the more recent Neanderthal material, such as that from Israel, dated about 30,000 years ago, shows aspects of modern features. It has been suggested that remains found at some late fossil sites indicate interbreeding between Neanderthal and Cro-Magnon, which is to be expected if they were contemporaries.

Cro-Magnon Man The last chapter of our very brief examination of the evolution of humans begins between 40,000 and 50,000 years ago and extends to 10,000 years ago. The best-known fossils belonging to that era come from the Cro-Magnon rock shelter in France — five adult *Homo sapiens sapiens* skeletons of both sexes, plus a premature infant. The Cro-Magnon skull (Figure 4.10) that we usually see pictured belonged to a male about fifty years old. He, and we, differed from Neanderthals mainly in having a skull that is shorter front to back with a higher dome, a smaller (vertically shorter) face with the forehead more nearly vertical, only slight brow ridges, and a more prominent chin. Brain size for Cro-Magnon fossils averaged 1,400 cubic centimeters for females, 1,600 for males.

Thus this example of Cro-Magnon is of modern appearance, even more so than some of us. If we look around among any group of people we see considerable variation in skull shape; many people have more sloping foreheads and less prominent chins than the Cro-Magnon pictured in Figure 4.10. But the same was true of Cro-Magnons. Many had skulls somewhat more Neanderthaloid in appearance, and there were racial variations, as well as variations within populations, just as there are today.

5

Heredity and Behavior

Every Individual Is Unique

Cells and Eggs

Chromosomes and Genes

Cell Division and Gamete Formation

Why Reproduce Sexually?

Genes and Behavior

Supplement 1 Can IQ Change?

Chapter Preview

Heredity and environment work together in the development of all characteristics of organisms—anatomical, physiological, and behavioral. Genes carry instructions for such things as eyes and eye color, and for neural circuitries that make behavior possible. Since each of us looks and behaves differently than anyone else, it is not surprising that people (except identical twins) are all genetically different.

All organisms are composed of cells, each containing a nucleus with chromosomes. Chromosomes are composed of genes, and both are made of DNA. The chromosomes occur in pairs, with one member of each pair inherited from each parent. The genes occur in pairs also, and the members of a pair affect the same characteristic. *Genotype* refers to an organism's genetic constitution, while *phenotype* refers to an observable characteristic. If one gene of the genotype for a particular characteristic is dominant and the other recessive, the effect of the dominant gene will be expressed in the phenotype.

Meiosis is the type of cell division that produces gametes—eggs or sperm. During meiosis the genetic information received from one's parents is mixed in two ways: (1) by crossing over, in which chromosomes of a pair exchange genes; and (2) by independent assortment of chromosomes in such a way that each gamete receives some chromosomes from each parent. Each gamete receives only one chromosome of each pair. Because of the mixing, all gametes are genetically different.

Thus sexual reproduction is more than simply a means of producing offspring. It is a mechanism for producing different genetic mixtures that will result in a variety of individuals, and so aid in adaptation and evolutionary change.

The genetics of behavior is the same as the genetics of anatomical or physiological characteristics. Some behaviors are influenced by a single pair of genes. Examples are sexual behavior in mice, phenylketonuria in humans, and nest building in parrots. Polygenic characters are influenced by several pairs of genes acting together. The chapter explores ways of recognizing whether a trait may be polygenic, and discusses maze running in rats and human intelligence as examples.

The supplement to this chapter discusses possible genetic influences on IQ and studies that demonstrate often dramatic changes in IQ during an individual's lifetime.

Behavior genetics is concerned with the nature and the degree of hereditary influences on behavior. All behaviors, like all anatomical and physiological characteristics, are determined by heredity and environment working together.

Thus **genes** do not *do* behavior, any more than they *make* eyes or eye color. Genes carry instructions, or programs. Given proper environmental conditions, these instructions will be carried out. If proper nutrients can be obtained from the environment, eyes will be built, colored with certain pigments, and a particular neural circuitry will be constructed that is capable of causing or allowing the organism to perform a certain behavior. Normally the behavior will be performed only in response to certain environmental conditions, and in fact environmental stimuli usually must be present for normal development of the behavior to occur.

Darwin was right when he claimed that evolution works by natural selection, and he knew that variations occurred and were inherited by offspring. But Darwin did not understand *how* the variations were inherited, much less how they came about in the first place. It was another forty years before the scientific world began to learn how variations are passed from generation to generation, and much longer before the origin of those variations was understood.

The basic principles of genetics were discovered by an Austrian, Gregor Mendel, and published in 1866. Unfortunately, Mendel's work went largely unnoticed, and it was not until 1900 that his ideas were rediscovered by other workers and the study of genetics again got underway. We now know that Darwin was aware of Mendel's work in time for later editions of his book, but apparently thought it unimportant. However, Darwin had succeeded where Mendel had failed. Darwin "sold" his ideas to the scientific community by publishing them with over three hundred pages of supporting arguments. In contrast, Mendel's paper was brief, and published in an obscure journal of horticulture; it went virtually unnoticed.

Every Individual Is Unique

One of the most important things genetics teaches is that every individual is genetically unique—genetically different from every other individual. (Of

Gregor Mendel discovered how heredity works and published his results in 1866. The science of genetics, however, did not really get underway until 1900 when other scientists finally recognized the importance of his work.

course, individuals developing from a single fertilized egg, such as identical twins, are exceptions.) This holds for plants as well as for people and other animals. We know this is true from evidence too lengthy to present here. In fact, we know that there are *many* genetic differences between any two individuals.

Individual differences are easiest for us to see among people, the organisms with which we are most familiar. No two people look alike because they are genetically different. And usually only facial features are considered in such a comparison. In fact people are also different in other physical characteristics, as well as in physiological and behavioral traits.

We emphasize differences when talking about genetics, but we should not lose sight of the fact that a human is a human because of his or her genetic constitution. A very large number of genes are *fixed,* in that they never, or very rarely, **mutate** —the genes that provide us, like the other apes, with four limbs, five fingers on each of two hands, an ear on each side of one head, and so on.

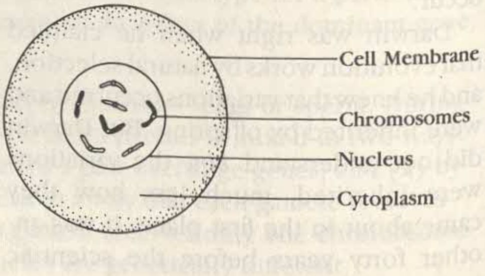
Genetic studies, however, can only work with genes that have mutated. If some individuals have mutated forms of genes that are detectable, we can study the normal genes and their mutants. With humans, this is done by tracing family lineages and noting which individuals display a certain characteristic. With animals and plants these genes and their effects are studied by crossing (mating) individuals carrying the mutant with each other and with normal individuals.

Cells and Eggs

All animals and plants, and all their organs and tissues, are composed of **cells.** Most cells are very small and can be seen only through a microscope. Their structure and function are fascinating, but only a slight knowledge of cells is needed for our study of basic genetics.

Very simply, a cell is a bag of substances with a nucleus inside. A simple

FIGURE 5.1 Diagram of a cell.



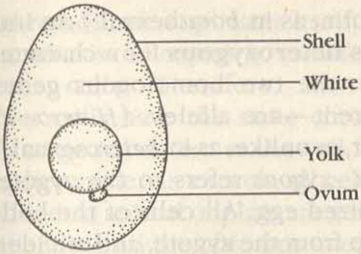


FIGURE 5.2 Diagram of an egg.

diagram of a cell is shown in Figure 5.1. The nucleus contains the chromosomes, which carry the heredity information. Each cell in an individual contains all the hereditary information for that individual.

The diagram of the cell in Figure 5.1 looks something like an egg, but an egg is not a cell. A simple diagram of an egg is shown in Figure 5.2. The **ovum** is the female reproductive cell. The small white or transparent mass on the yolk of an egg contains the ovum. We often say "the fertilized egg" when we mean the fertilized ovum. The egg, however, is not fertile unless the ovum has been joined by a **sperm.** The "fertilized egg," or fertilized ovum, is called the **zygote.**

Chromosomes and Genes

The word **chromosome** comes from the Greek (*chroma,* color; *soma,* body); the name derives from the fact that it is a body that can be stained with color dye. Chromosomes are the carriers of hereditary information, and consist of long chains of genes. A *gene* is the carrier of hereditary information affecting a particular characteristic. Genes are arranged in a linear sequence, forming a chromosome. Hundreds of genes are included in a large chromosome.

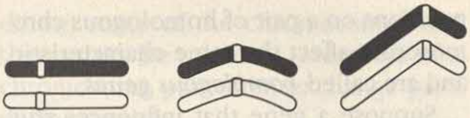


FIGURE 5.3 Three pairs of chromosomes. For this and subsequent diagrams we represent individual chromosomes of a pair in different colors. We represent the pairs as differently shaped (straight, curved, angled) so that each can be followed through the stages of meiosis. In reality, the members of a pair look quite alike. Chromosomes are flexible and vary in shape at different times, and the centromeres do not bulge. The centromeres are involved in pulling the chromosomes to opposite ends of the cell during division.

Each cell of a human or a fruit fly or any organism contains chromosomes, and each chromosome contains a number of different genes along its length in a definite and constant order. The genes influence what the animal will be like behaviorally as well as anatomically and physiologically.

Chromosomes and the genes that form them are composed of long strands of deoxyribonucleic acid, **DNA** for short. DNA is made up of many complex molecules. However, we can omit the details of these molecules and represent chromosomes in a general diagram (Figure 5.3).

In humans and most other organisms the chromosomes occur in pairs. Humans have twenty-three pairs of chromosomes, drosophila flies four pairs, pigeons forty pairs. One member of each pair came from the female parent, the other from the male parent.

The two members of a pair of chromosomes carry genes affecting the same characteristics, and therefore the genes also occur in pairs. The members of a chromosome pair are called **homologous chromosomes,** or *homologs.* Particular genes are located at particular positions along the length of a chromosome. Two genes at corresponding positions on a pair of homologous chromosomes affect the same characteristic, and are called *homologous genes.*

Suppose a gene that influences stuttering is located at a position halfway down a chromosome that a boy received from his mother. If it were possible to examine that chromosome's homolog, one he inherited from his father, we would find a gene affecting speech located in the same position. In a different position we would find a gene that influences a different characteristic.

Two homologous genes may be identical (for example, both genes for stuttering), or they may be different (one for stuttering and the other for normal speech). If the two genes are identical, the characteristic they encode will be expressed in the individual. Thus an individual with both genes for stuttering would be expected to stutter.

If the homologous genes are different they are called **alleles.** The characteristic that is expressed will depend on the relationship between the alleles. If a person has one gene for stuttering and the other for normal speech, the characteristic expressed will be normal speech. This is because the allele for normal speech is **dominant.** The characteristic influenced by a dominant allele will be expressed whether it is paired with an identical gene or with its allele. The allele for stuttering is **recessive.** Normally a characteristic influenced by a recessive gene will be expressed only when the individual has two (identical) recessive genes for that trait. Thus a person who stutters would have to have both genes for stuttering. Note that not all alleles have a dominant-recessive relationship.

We say that an individual is **homozygous** for a particular characteristic when the genes influencing that characteristic are identical. (*Homo-* means similar or uniform, as in *homo*sexual.) An individual is **heterozygous** for a characteristic when the two homologous genes are different—are alleles. (*Hetero-* means other, or unlike, as in *hetero*sexual.) The suffix *-zygous* refers to the zygote, the fertilized egg. All cells of the body develop from the zygote, and are identical to it in genetic constitution.

By now it may be apparent that we need to make a distinction between the genetic information an organism contains and the characteristics that are expressed. Many of the genes we inherit from our parents may not be expressed. You may have a gene for stuttering, but if it is paired with one for normal speech you will not stutter. **Genotype** refers to the genetic information that an organism has inherited, while **phenotype** refers to the anatomical, physiological, or behavioral characteristics that are expressed.

Cell Division and Gamete Formation

You have probably encountered *mitosis* and *meiosis* before. They are the two types of cell division that occur in living organisms, and both are concerned with getting chromosomes into daughter cells. In genetics we are not particularly concerned with mitosis, so we will review only briefly and then examine meiosis in more detail.

Mitosis

Mitosis is the type of cell division that occurs during the growth and development of an individual, beginning with the division of the fertilized egg. During mitosis, a cell divides and two daughter cells are formed. Before mitosis occurs each chromosome duplicates itself, and during mitosis the copies go to different daughter cells. Therefore, the two daughter cells have the same chromosome and gene content as the cell from which they came. As a result, all cells in the individual animal or plant are genetically identical; all the chromosomes the individual received from its parents are present in all cells of that individual.

Meiosis

Meiosis is of great importance in genetics. It is also an essential part of sexual reproduction. Meiosis occurs only in the reproductive organs, and is the type of cell division that produces **gametes**—eggs or sperm.

Recall the following:

1. Chromosomes, and genes, occur in pairs.
2. Chromosomes are groups of genes.
3. Genes influence characteristics.
4. Many genes have alleles.
5. Every individual is genetically unique, carrying a combination of alleles different from any other individual, although the genes at any position may be identical rather than alleles. (Identical twins are an exception.)

When an individual produces gametes, the genetic information inherited from each parent is mixed. As a result of meiosis, the eggs or sperm produced by an individual are usually all genetically different.

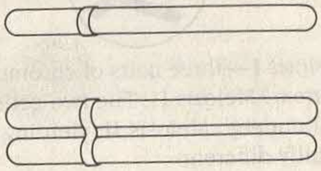
Each gamete contains only one chromosome of each pair. The one chromosome of a pair in a particular gamete may be from either of the individual's parents, so that among the many chromosomes in a gamete there is nearly always a mixture, some chromosomes from the mother and some from the father. In addition, some of the chromosomes will themselves be mixtures. Members of a chromosome pair often exchange parts during meiosis.

Therefore, each sperm or egg contains a mixture of the genetic information the reproducer received from its parents, and it has been mixed in two ways.

Meiosis consists of two cell divisions, called *Meiosis I* and *Meiosis II*. In Meiosis I, one cell divides to produce two cells that are genetically different. In Meiosis II the two cells each divide, producing a total of four which are, again, all genetically different. The differences are due to the processes called *crossing over* and *independent assortment*.

Crossing Over Before meiosis occurs, each chromosome produces an exact copy of itself, and the duplicates are held together by the **centromere** (Figure 5.4). After duplication homologous chromosomes come together, and all along the length of the chromosomes homologous genes also come together. While the homologs are together, **crossing over** occurs. Some or all chromosomes exchange parts, but the exchange is only between homologous chromosomes. The parts exchanged ordinarily contain equal numbers of genes (Figure 5.5). Then the homologous chromosomes go to opposite sides of the cell.

FIGURE 5.4 *(Top)* Original chromosome. *(Bottom)* Duplicated chromosome. In reality, the duplicated chromosome is constricted at the centromere; the centromere duplicates later than the rest of the chromosome.



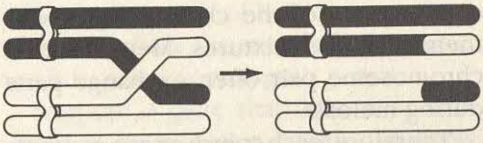


FIGURE 5.5 A crossover occurs only between homologous chromosomes. Equal parts are exchanged. The result is a mixing of genetic information from the parents.

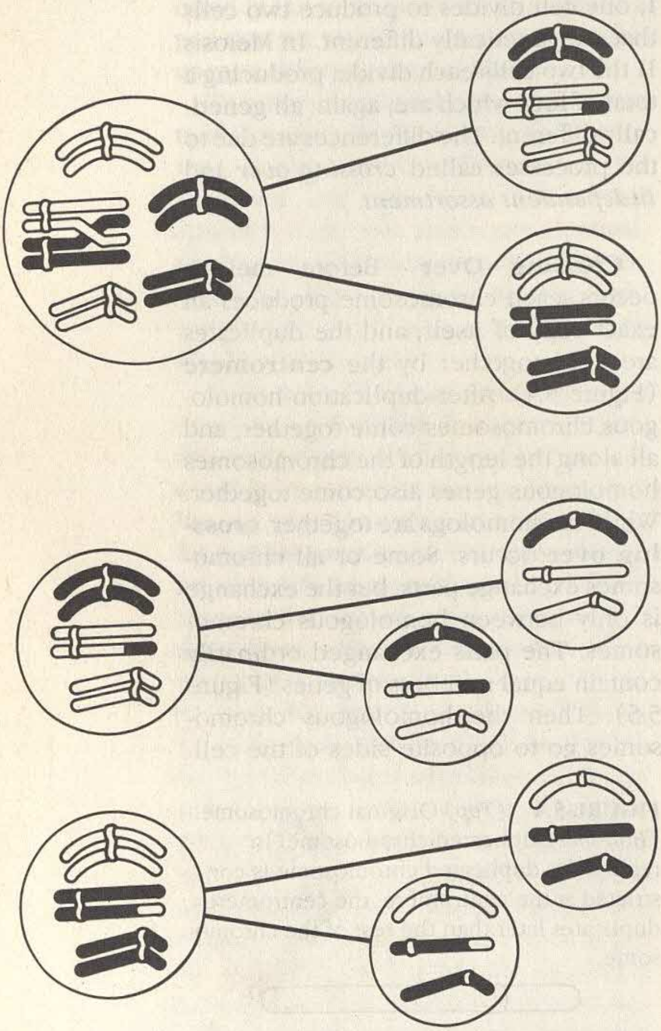


FIGURE 5.6 *(Top)* Meiosis I—three pairs of chromosomes and one crossover. *(Bottom)* Meiosis II. The two cells resulting from Meiosis I undergo Meiosis II, yielding a total of four cells, all genetically different.

Finally the original cell pinches in two. The resulting cells each contain one chromosome of each homologous pair, and so of course one gene of each pair. This outcome is in accordance with Mendel's first law, the Law of Purity of Gametes: each gamete contains only one gene of each pair, and thus is pure for each gene. Meiosis I is now complete (Figure 5.6).

Independent Assortment During Meiosis I, when homologs go to opposite sides of the cell, the members of different pairs of chromosomes assort independently of the way members of other pairs assort. For example, a member of one pair that was received from the mother may go to the same side of the cell as a member of another pair that came from the father. Thus the members of different pairs undergo **independent assortment**—the chromosomes from the two parents of the individual producing the gametes end up in various combinations, and the combinations are different from one meiotic division to the next.

The top portion of Figure 5.6 illustrates *one* way the chromosomes could have assorted during Meiosis I. Because members of different pairs of chromosomes assort into the gametes independently of other pairs, any combination of chromosomes may occur, but there must necessarily be one of each pair; in the example in Figure 5.6 one straight, one curved, and one angular. The two members of a pair look entirely alike. In the figure one is darkened so that we can follow individual chromosomes and parts of chromosomes in this and the following examples.

The two cells resulting from Meiosis I are different. The reason is that each of the cells contains only one homolog

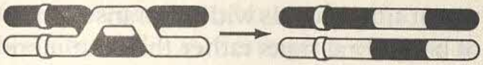


FIGURE 5.7 A double crossover.

of each original pair of chromosomes, and the members of a pair carry different alleles of many of the genes. Also, crossing over further mixes the genetic material.

In order for crossing over to occur, the chromosomes must break, and breakage occurs between the same two genes on each homolog. The result is an exchange of equal parts, of equal groups of genes. Also, crossing over may occur at more than one place, resulting in double or triple or more crossovers (Figure 5.7).

In Meiosis II (Figure 5.6, bottom), the centromeres duplicate, and the chromosomes go to opposite sides in each of the two cells. Each cell pinches in two, resulting in four gametes. As you can see, the four cells resulting from a complete meiotic division, Meiosis I plus Meiosis II, are genetically different.

In males the products of meiosis are four sperm. Meiosis occurs many times in males before mating, and many sperm are transferred to the female. Only one sperm fertilizes the egg, and it is a matter of chance which one that will be.

In females only one of the four cells resulting from meiosis becomes the ovum; the other three degenerate. However, it is a matter of chance which of the four will be the ovum.

It is important to remember that each of the two individuals involved in reproduction contributes to a gamete only half of the chromosomes received from its parents, and in only one of many possible combinations. For example, humans have 23 pairs of chromosomes. The number of *possible* different mixtures of chromosomes in the gametes is 2^{23}, or 8,388,608. Add to that the crossovers between members of pairs, and the number of possible recombinations of genetic material in the gametes produced by an individual becomes extremely large.

So it is easy to see why there are so many differences among individuals: genetic information is mixed and remixed from generation to generation. This has great survival value for any sexually reproducing species. It gives natural selection many differences to select among, and that allows evolutionary improvement to occur.

Why Reproduce Sexually?

Sexual reproduction is almost universal among living things. Even most unicellular organisms reproduce sexually at frequent intervals, although they reproduce asexually a majority of the time. *Asexual* reproduction eliminates the necessity of locating a suitable mate, and is also much more energy-efficient. There is no need to compete with other individuals for a mate, to set up and defend a territory, or go through elaborate courtship rituals. In many birds these rituals are preceded by an additional energy drain—growing a new set of colorful feathers. Many aquatic **invertebrates** release very large numbers of eggs into the water which may or may not come together with sperm released by other individuals of the species. Eggs carry a substantial amount of stored energy, which is wasted if fertilization does not occur, and the manufacture of sperm requires energy also, although less. Moreover, males of many species are with females only long enough to contribute sperm, and do not take part in feeding and caring for the young. Males of these species could be viewed as heavy consumers of resources whose only contribution to the welfare of the species is the furnishing of a few sperm in the spring.

Thus sexual reproduction is expensive in a number of ways. Why is it that sexual reproduction is so nearly universal? Why not just eliminate it?

Different "family lines" carry different genetic variations. With strictly asexual reproduction there is no way these variations can get together in the same individual, yet it is often advantageous if they can. Genetic variants frequently work far better together than separately: their combined effect may be more than additive, or they may complement each other.

Two mating individuals are commonly from different family lines and carry different genetic variations. Meiosis occurs in both individuals, and because of crossing over and independent assortment various mixtures of their genes are passed into their gametes. Different offspring receive various combinations of genetic information, and these are again mixed by meiosis when the offspring produce gametes.

Thus sexual reproduction provides for extensive genetic variation, and genetic variation provides the raw materials that natural selection works on. Single-celled organisms are very instructive here. They regularly reproduce asexually and would therefore be in a good position to eliminate sexual reproduction, if sexual reproduction did not have advantages that outweigh its apparent inefficiency. However, after producing several generations asexually, most single-celled organisms then reproduce sexually.

Genes and Behavior

Behavior genetics works no differently from the genetics of other characteristics. It simply deals with the transmission of behavioral traits rather than the more commonly used examples, such as eye color or plant height or some other physical trait. However, behavior genetics is more difficult to investigate, and far fewer examples are available.

Simple Patterns of Inheritance

Sexual Behavior in Mice Two of the fur color mutants in mice are black and albino (white). Male albino mice were found by Levine (1958) to be more successful than black mice in fathering litters of offspring from albino females. In each of ten trials, three mice were placed together in a cage: a male and female albino and a black male. Ten litters of baby mice were obtained from each of the ten trials. Of the 100 litters, 76 were all white and therefore were fathered by the albino male; 12 litters were all black, and therefore fathered by the black male; and 12 included some white individuals and some blacks, indicating that both males had bred with the female in producing those litters.

Initially these data were interpreted to mean that the albino male was more successful in inducing the female to mate, and this may be true. However, later observations indicated that male albinos usually won in fights with male blacks. Therefore, breeding success for the albino males may have been due to their fighting success—their ability to keep the black males away from the females—rather than superior courtship behavior.

But let us return to genetics. Problem: How can we tell who fathered which litters?

Let c^1 stand for albino, and c^2 stand for black. Every mouse has one pair of genes for coat color. A pure albino would therefore be represented by c^1c^1 and a pure black by c^2c^2. Only one gene of a pair is present in a gamete. We can diagram a cross between two albino mice this way:

$P_1 \longrightarrow$ c^1c^1 × c^1c^1
(parents) (white) (white)

gametes $\longrightarrow$ 100% c^1 100% c^1

$F_1 \longrightarrow$ 100% c^1c^1
(offspring) (white)

A cross between a black and an albino:

$P_1 \longrightarrow$ c^2c^2 × c^1c^1
(black) (white)

gametes $\longrightarrow$ 100% c^2 100% c^1

$F_1 \longrightarrow$ 100% c^2c^1
(black)

Thus youngsters fathered by an albino male, as in the first cross, would all be white. Those fathered by a black male would all be black, as in the second cross. The offspring in the second cross are black because black is dominant to albino, and expresses itself even in the presence of the recessive albino gene.

Recall that *genotype* refers to the genetic constitution, and *phenotype* refers to the product of the genes interacting with the environment. The phenotype may be a color, as in this example, or some other structural trait, or a physiological or behavioral trait. Mice that are genotypically c^1c^1 are phenotypically white. They are also phenotypically more successful at fathering litters; perhaps they are phenotypically better fighters, or perhaps they are phenotypically better at courtship. Mice that are genotypically c^2c^2 are phenotypically black, and presumably phenotypically worse fighters or lovers, or both. Mice that are genotypically c^2c^1 are phenotypically black; we know nothing else about their phenotype from the information at hand.

We can carry the above example a step further, and mate two individuals from the F_1 generation of the last example:

$P_2 \longrightarrow$ c^2c^1 × c^2c^1
(black) (black)

gametes $\longrightarrow$ 50% c^2, 50% c^1 50% c^2, 50% c^1

$F_2 \longrightarrow$ 25% c^2c^2, 50% c^2c^1, 25% c^1c^1
(black) (black) (white)

(Note that while the F_2 genotypes are in a 1 : 2 : 1 ratio, the F_2 phenotypes are in a 3 : 1 ratio.)

This does not tell us how many offspring there will be — there may be only one, and it could be c^2c^2 or c^2c^1 or c^1c^1. But of a large number of offspring, about 25 percent will be c^2c^2, about 50 percent will be c^2c^1, and about 25 percent will be c^1c^1.

Phenylketonuria in Humans The genetics of **phenylketonuria** (PKU) works exactly like the previous example, because the gene p that is responsible for PKU is recessive and its allele P for the normal condition is dominant. We can simply substitute P for c^2 and p for c^1 in the above diagram to show the results of crossing two individuals who are phenotypically normal but are carriers of PKU:

$P_1 \longrightarrow$ Pp × Pp
(normal carrier) (normal carrier)

gametes $\longrightarrow$ 50% P, 50% p 50% P, 50% p

$F_1 \longrightarrow$ 25% PP 50% Pp 25% pp
(normal) (normal carrier) (has PKU)

Normal individuals, those of the genotypes *PP* or *Pp*, can produce the enzyme phenylalanine dehydroxylase and therefore can metabolize phenylalanine. One of the essential amino acids, phenylalanine is present in many foods, but is needed only in small amounts. In normal individuals the excess is converted to a harmless substance. But in individuals of the genotype *pp*, who do not produce the enzyme, phenylalanine accumulates to dangerous levels. Excess phenylalanine is associated with severe mental retardation. However, if the condition is detected shortly after birth the baby can be fed a diet low in phenylalanine, and PKU can be prevented. This is a clear example of the interaction of genes and environment. The normal environment provides the *pp* individual with more phenylalanine than it can handle, and the brain does not develop properly. Changing the environment by providing a diet low in phenylalanine allows the individual to develop normally.

Nest Building in Parrots Sometimes it is possible to cross two closely related species in the laboratory, even though they would not mate and produce offspring in nature. Such an experiment was done with two closely related species of small parrots, *Agapornis personata* and *A. roseicollis* (Dilger, 1962).

In the laboratory, both these parrots use paper strips in nest building, but one species carries the strips in their beaks, and the other tucks them in among the flank feathers. Hybrids display both behaviors in a manner that might be described as confused. Hybrids hold a strip in their beaks, tuck it among the flank feathers, then take it out again, only to place it again among the flank feathers. This may be repeated many times before the birds ultimately carry the paper strips to the nest, sometimes in the beak and sometimes among the flank feathers.

It is obvious that the hybrids have genetic information for both behaviors, and these results suggest that the difference between the two species in nest material carrying may be due to a single mutation. Further, the alleles would appear to be **codominant,** meaning that both express themselves when together; neither gene is dominant or recessive.

Consider a diagram of the cross, using the symbols C^f for flank-carrying and C^b for beak-carrying:

$$\begin{array}{lll} P_1 \longrightarrow & C^fC^f \times & C^bC^b \\ \text{gametes} \longrightarrow & C^f & C^b \\ F_1 \longrightarrow & C^fC^b & \end{array}$$

What the diagram says is that a mating of a flank-carrier with a beak-carrier should produce offspring that perform both behaviors if the genes are codominant. This is not an unusual situation. Many instances are known in which neither allele is dominant.

Polygenic Inheritance

Polygenic ("many-gene") traits are those controlled by more than one gene pair. They are difficult to analyze beyond the point of establishing that they are polygenic; how many gene pairs are involved is usually unknown.

One polygenic trait that *is* understood is seed color in wheat, which is governed by three pairs of genes. (Human skin color, at least the broad categories usually called "black" and "white," is probably determined in a similar manner, perhaps by four gene pairs.) Each of these six genes in wheat (or the eight genes in humans) either causes the manufacture of pigment or causes it not to be manufactured. If a wheat plant has six genes for pigment production, the seeds will be dark brown. A wheat plant with six genes for nonproduction of pigment will have white seeds. A plant with only one of the six for pigment production will be only slightly colored, one with three of each will be an intermediate shade, and so on.

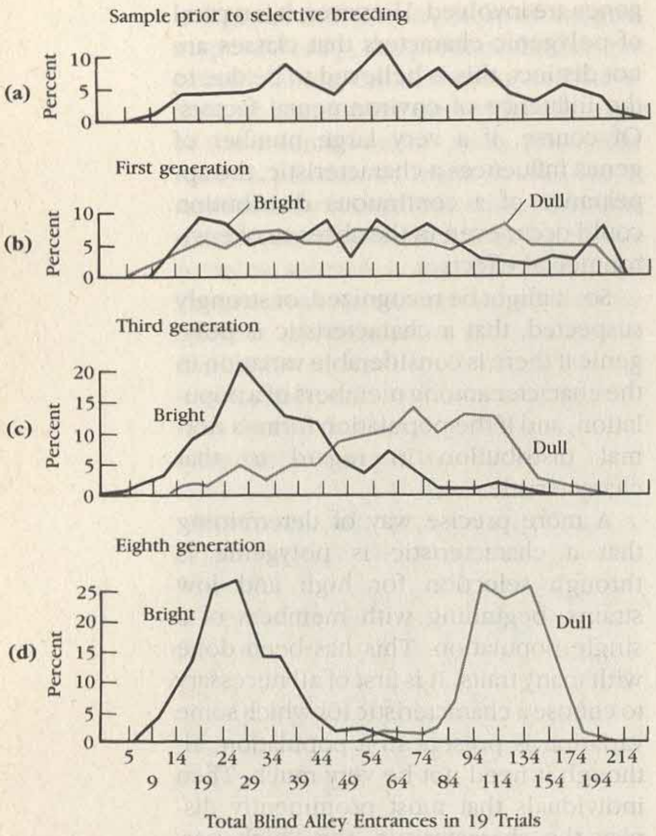
Human height is a polygenic characteristic with which we are all familiar. We know a few very short people and a few very tall people, but the majority are intermediate between the two extremes, and these intermediates tend to cluster around an average height. All the heights plotted together would form a curve similar to the *normal distribution,* the so-called bell-shaped curve (see Figure 3.5).

Recognizing Polygenic Traits Human heights extend over a fairly broad range, and are separable into distinct classes only arbitrarily. For example, a woman between 5 feet $8\frac{1}{2}$ inches and 5 feet $9\frac{1}{2}$ inches tall would usually be said to be 5 feet 9 inches tall, even though her exact height may be 5 feet $8\frac{25}{32}$ inches. This sort of continuous distribution strongly suggests that human height is polygenically determined, although environmental factors such as nutrition can be expected to influence height and cause some variation. Even though several genes are involved, human heights *should* separate into distinct classes. For example, some people should be exactly 5 feet 8 inches and others exactly 5 feet 9 inches, or some other distinct increment, because each gene is expected to be responsible for a certain increment in height or no increment at all, similar to the wheat example. Thus human heights should fall into distinct classes, with a gap between the classes. If they did it would be easy to calculate how many genes are involved. However, it is typical of polygenic characters that classes are not distinct; this is believed to be due to the influence of environmental factors. Of course, if a very large number of genes influences a characteristic, the appearance of a continuous distribution could occur even in the absence of environmental effects.

So, it might be recognized, or strongly suspected, that a characteristic is polygenic if there is considerable variation in the character among members of a population, and if the population forms a normal distribution in regard to that characteristic.

A more precise way of determining that a characteristic is polygenic is through selection for high and low strains, beginning with members of a single population. This has been done with many traits. It is first of all necessary to choose a characteristic for which some variation is present in a population, although it need not be very much. Then individuals that most prominently display the characteristic, the "high performers," are mated together, as are the "low performers." The highest performing individuals from among the F_1 of the high performers are selected for breeding, and the lowest performers from among the F_1 of the low performers. By following this procedure it is possible, after several generations, to develop high- and low-performance strains, which often display the characteristic of interest far more than did the original parents.

Maze Running in Rats One of the first and best-known behavior selection experiments was done by R. C. Tryon (1940), who selected rats for high and low ability to learn to negotiate a maze (Figure 5.8). Tryon called them "bright"



Sample prior to selective breeding

First generation

Third generation

Eighth generation

FIGURE 5.8 Tryon's selective breeding data for maze running in rats.

and "dull" strains, but note that he only knew they were bright or dull with regard to running a particular maze: the bright strain could learn to run the maze relatively quickly, and the dull strain learned slowly. We know nothing of their other abilities.

Tryon tested the members of a population of laboratory rats and found that they varied considerably in their ability to learn to negotiate a maze. The quickest learners made only 9 errors in 14 trials, while the slowest made 214 errors in 14 trials (Figure 5.8a). Tryon bred the quickest together and the slowest together, and in the second-generation offspring (Figure 5.8b) the ability curves for the two groups were distinct, although broadly overlapping. In the third generation the peaks of the curves were further apart with less overlap (Figure 5.8c). As we see in Figure 5.8d the ability curves are quite distinct and show very little overlap in the eighth generation.

The curve for maze-running abilities in rats is the same general shape as the curve for human heights—a more or less normal curve. Tests for maze running in *wild* rats might also produce a normal curve. However, perhaps natural selection in the wild has eliminated "dull genes"; wild rats that have difficulty finding their way around may not live long enough to produce many offspring. If this is true, then less variation would exist among wild rats, and therefore a curve of their maze-running abilities might be rather narrow, more like one in Tryon's eighth generation. But even if this is so, selecting and breeding for quick and slow maze learners should eventually produce two distinct groups among wild rats as well. For any trait that is affected by several genes it is normally possible to select for high and low strains, even if the original dispersion is not great. Note that in this example the genes being expressed were already present in the population; they were merely concentrated in certain individuals due to chance recombinations and selection.

Human Intelligence Like human height, measured intelligence is distributed normally or near normally, with most people's scores clustering around the average. For example, approximately two-thirds of the population of individual IQ scores range from 85 to 115 (100 is average), and 95 percent of the scores in the population fall between 70 and 130. Only a very small percentage of individuals, approximately 1 percent, attain scores lower than 55 or higher than 145. The bell-shaped distribution of IQ scores raises the possibility that human intelligence may be a polygenic character.

Naturally, selection experiments cannot be performed on people to determine whether any of the variation we see in IQ is due to genetic factors. But Nature has provided her own "experiments," which may shed some light on this question. One of these natural experiments involves comparisons of identical (**monozygotic**) twins with fraternal (**dizygotic**) twins. Monozygotic twins develop from a single fertilized egg (*mono* means single), and dizygotics from two separate fertilized eggs (*di* means two). The key here is that identical twins have identical *genotypes,* but fraternal twins do not. On the average, fraternals have about 50 percent of their genetic information in common, which is the same as for siblings who are not twins.

So if we were to find that identical twins are more similar than fraternals in IQ, or in any other trait, one explanation might be that the greater trait similarity for identicals reflects these twins' greater *genetic* similarity. An example will help to illustrate this point.

Suppose we select several pairs of identical twins and arbitrarily designate one member of each pair "member A" and the other "member B." Then we give each member of each pair an intelligence test, record the scores for all the A members, and do the same for the B members. Finally, we calculate a correlation coefficient to determine whether there is any relationship between the A and B scores. Now we repeat this process using several pairs of *fraternal* twins, and then compare the identical twin correlation with the fraternal twin correlation. Let us say we actually went through these procedures for several pairs of identical twins and several pairs of fraternal twins, and obtained a correlation for identicals of .90 and a correlation for fraternals of only .50. The higher correlation for identicals would support a genetic interpretation of IQ. These correlations are fictitious, but they approximate average correlations for actual data from twin studies carried out over the years. The correlation for identical twins is higher than that for fraternals, and it may well be that the greater *genetic* similarity of identical twins has something to do with this. However, a strictly genetic interpretation of these results must assume that the degree of *environmental* similarity for identical twins is the same as it is for fraternal twins. If it is not — for example, if identical twins are treated more alike by their parents and others than are fraternal twins — then the higher correlation for identicals could be a reflection of their greater environmental, rather than genetic, similarity. In other words, we cannot make a clear genetic or environmental interpretation of data derived from comparisons of identical with fraternal twins, because genetic and environmental similarity may be *confounded;* the greater genetic similarity of identical twins may be accompanied by greater environmental similarity.

In fact, there is some evidence that parents of two-and-a-half-year-old identical twin boys do tend to treat them more similarly than do parents of boys the same age who are fraternal twins (Lytton, 1977). Whether such differential treatment could result in the identical-fraternal differences in correlations of IQ scores is an unresolved question.

Clearly, there is a need to go beyond the identical-fraternal comparison if we are to be able to determine unambiguously whether genetic factors influence intelligence. For example, one approach might be to compare fraternal twins with ordinary siblings. When such a comparison is done for a large number of studies, the median correlation for fraternal twins turns out to be about the same as for ordinary siblings, approximately .50. Also, whether the fraternal twins are of the same or different sex makes no difference in the correlation. We might expect that fraternal twins, particularly those of the same sex, would have more similar environmental experiences than non-twin siblings do. But if this is so, it is not reflected in the correlations. The correlational data are, however, quite consistent with a genetic interpretation.

Perhaps the most sensitive "natural experiments" for determining whether genetic factors influence intelligence are *adoption studies.* There are now a number of studies that have compared the intellectual performance of children with that of their biological parents and that of their adoptive parents. Even in cases in which children were placed in foster homes as infants, the obtained correlations between IQ scores of children and those of their biological parents turn out to be higher than those between the scores of children and of their foster parents (Munsinger, 1975, 1978; Scarr & Weinberg, 1977). Munsinger (1978) averaged the correlations from all of the published adoption studies of intellectual performance he could find, with the following results:

1. The average correlation between adopted children and their foster parents (no genetic similarity between children and parents, but same environment) was .14.
2. The average correlation between adopted children and their biological parents (genetic similarity between children and parents, but different environments) was .46.
3. The average correlation between nonadopted children and their biological parents (genetic similarity between children and parents, and same environment) was .48.

Correlational data from adoption studies most certainly point to the existence of a genetic influence on measured intelligence. The correlations for genetically related individuals living together *or* apart are typically much higher than correlations between genetically unrelated individuals living together. Does this mean that the environment has little or no influence on intellectual performance? Absolutely not. In one adoption study (Skodak & Skeels, 1949) the absolute values of adopted children's IQs averaged twenty-one points higher than those of their biological mothers. The foster parents were generally better educated and from a higher socioeconomic class than were the biological parents, so perhaps more stimulating foster environments were responsible for the higher IQs of the children.

Based upon the evidence accumulated thus far, it would seem that there is genetic influence on measured intelligence. This is true even for indicators of intelligence in infants (see, for example, Matheny, 1980). In other words, genetic variation among individuals is responsible in part for individual differences in intellectual performance. And, as with other polygenic characters, environmental influences also contribute to the variability we see in measured intelligence.

Other Polygenic Traits In addition to intelligence, many other human behaviors and traits are distributed in a bell-shaped curve. And there is evidence, mainly from twin studies, that genetic factors may account in part for the variation observed in some of these traits. Possible contenders for a polygenic explanation include activity level, irritability, aggressiveness, sociability, the need for environmental stimulation, and certain forms of abnormal behavior. The evidence for genetic influence on these traits generally is weaker than it is for measured intelligence, but this may be due to the fact that many of these traits are more difficult to define and assess reliably than is intellectual performance. We discuss several of these apparently polygenic behavioral characters in later chapters.

A number of characteristics—structural, physiological, and behavioral—are polygenically controlled. Polygenic variation among offspring has survival value because it allows changing responses to changing environmental conditions, much as the populations in some of the examples discussed in this chapter responded to different environmental conditions imposed by the experimenters.

Supplement 1. Can IQ Change?

Objective tests of intellectual performance were invented in the early 1900s in order to predict how well or poorly children would perform in the classroom. And although there is much controversy over the meaning of an IQ score, the fact is that IQ tests do a fairly good job of identifying those who are likely to succeed or fail in traditional middle-class school environments. Because of this predictive relationship between IQ and academic performance, many psychologists during the first half of the twentieth century assumed that IQ reflected a general learning ability that was **innate** (inherited). Because they thought it was innate, it seemed to follow that this general learning ability was fixed for individuals throughout most of their lives. Thus, they reasoned, IQ scores should show relatively little change over time.

We now have a great deal of information from long-term studies of persons who have been given IQ tests repeatedly during the course of their lives. Results of these studies typically have been reported in the form of correlation coefficients. For example, a group of children might be tested at ages 7, 9, 11, 13, and 15 years. IQ scores at age 7 would be correlated with those at later ages. The correlations from studies such as these generally have been quite high. After age 6 the correlations are seldom lower than .80, and during the late teens the correlations often exceed .90 (Bayley, 1949). Until recently these high correlations were interpreted as suggesting that IQ remains relatively constant over time, and thus is probably influenced very little by the environment, the developmental status of the child, or other factors. However, during the 1970s several investigators (for example, McCall, Appelbaum, & Hogarty, 1973) correctly pointed out that correlation coefficients do not necessarily say anything about changes in IQ over time for *individuals* or even for *groups* of individuals. That is, a high positive correlation between two sets of scores simply means that the rank order of one set of scores resembles the rank order of another set. Let us say that Mary gets the highest IQ in a group of subjects tested at age 13, John and Sarah come in second and third respectively, and Sam, George, and Susan score lower than the others. A high positive correlation (say, .95) between these subjects' scores at age 13 and their scores at age 15 would mean that Mary, John, and Sarah would also be at the top of the group tested at age 15, and that Sam, George, and Susan would still be at the bottom. However, the correlation would *not* reflect any changes that may have occurred in the IQ scores of these children between ages 13 and 15. Mary might have had the highest score both times, but her score could have been 115 at age 13 and 130 at age 15, an increase from the eighty-fourth to the ninety-fifth percentile for IQs of the entire population. This example of IQ change in the face of a high correlation between ages is fictitious, but it is not unrealistic. McCall and his colleagues have shown clearly that high correlations for IQ across age should not be interpreted as reflecting IQ constancy across age:

> *Group changes in IQ.*—Despite correlational stability, nearly every study which administered IQ tests to the same subjects at different ages has revealed some change in IQ for the entire group of subjects. . . . In nearly all of these projects there was a general rise in IQ over age for the group as a whole, although there was often a small group of subjects who declined in IQ.
>
> *Changes in individual subjects.*—Much of the evidence that IQ can change among normal children comes from case studies reported by . . . longitudinal projects. . . . For example, Sontag, et al. (1958) presented individual graphs of 140 children from the Fel's study who had been assessed 13 times between 3 and 12 years. The most dramatic increase was from an IQ of 118 at age 3 to 176 at age 11 (these are approximate values based upon averages of three assessments at adjacent ages). Probably the most impressive shift in IQ in the literature is for a boy who went from 78 at age 3 to 151 at 8 years, a shift of 73 IQ points (Moore, 1967). This represents a rise from approximately the 8th to the 99.9th percentile [McCall, Appelbaum, & Hogarty, 1978, pp. 3–4].

Thus it seems clear that the IQ scores of individuals can indeed change, and sometimes drastically. Does this mean there is no genetic influence on IQ? No. We presented evidence earlier in the chapter that supports the idea that genes influence IQ. But just because an ability or trait has a genetic basis is no reason to expect that it will remain fixed for life, or that it will be impervious to the effects of the environment.

6

Developmental Processes and the Beginnings of Life

Developmental Research Methods

Evolutionary Influences on Development

Maturation, Experience, and Development

Prenatal Development

Infancy

Chapter Preview

Development involves physical and behavioral growth and change related to age. A complete and accurate understanding of behavior requires that we examine the developmental histories of organisms as well as the developmental process itself.

Researchers use two major approaches in studying development — *longitudinal* and *cross-sectional*. The longitudinal approach involves observing behavior of the same subjects over time to see when and under what conditions the behavior changes. The cross-sectional approach simultaneously studies groups of subjects of different ages. Compared to the longitudinal approach, the cross-sectional is more economical in terms of time and expense, but is less sensitive to developmental trends in behavior.

Understanding the forces that affect development requires that evolutionary influences (the *why* of development) be considered, as well as the interplay between genetic instructions and the environment (the *how* of development). For example, one way to understand the long period of immaturity in human development is by considering the evolutionary advantages of possessing a large brain to support increased intelligence and language. Larger and more complex nervous systems require longer times for their development, hence the long period of immaturity.

In order to understand how developmental changes come about, it is important to know something about the concepts of maturation and experience. *Maturation* refers to the development of physical structures and functions. Maturational changes are under rather strict genetic control, but may be influenced by the environment. *Experience* refers to the encounters an organism has with its environment, encounters that can influence maturation and behavior.

A great deal of development takes place before birth. Human prenatal development is divided into three stages: the period of the *ovum,* the first two weeks following conception; the period of the *embryo,* third through eighth weeks; and the period of the *fetus,* from eight weeks to birth. Each stage is associated with distinct kinds of developmental patterns shaped by both maturation and experience. The proper timing of certain prenatal environmental events is crucial to normal development. Some prenatal environmental factors can result in fetal death or developmental disabilities; such factors are known as *teratogens.*

Human *infancy* includes the period of development spanning the first two years of postnatal life. Newborns, although helpless in many ways, come equipped with some remarkable behavioral capacities. They can see, hear, smell, and taste, and they display a wide variety of apparently adaptive reflexes and other capabilities.

Physical growth and *motor development* proceed rapidly during infancy, with head, neck, and central areas of the body growing fastest. Physical growth and motor development appear to be under strong genetic control, but environmental factors such as nutrition and visual experience are known to influence the timing of these phenomena.

Infants show many basic *perceptual* and *memory* capabilities early in life, which become more refined as the infant grows older. Infants also show evidence of possessing basic *conceptual* abilities.

Even very young infants provide signals that can *communicate* different messages to parents. Crying, looking, babbling, and smiling are all behaviors that may serve to elicit effective caregiving behaviors from parents. In addition to these nonlinguistic communicative signals, infants develop various *language* skills during the first two years of life. By two years of age most children have a sizable vocabulary, can form basic sentences, and can comprehend much more language than they can produce.

Definite *emotional* and personality characteristics may be present even in newborns, in the form of *temperament.* Individual differences in temperamental characteristics such as activity level and intensity of response appear early in infancy. One of the most prominent features of infant emotional development is the formation of an affectional bond between child and parent—*attachment.* The quality of attachment may have an important bearing on later development.

Development refers to growth and change in an organism, both physical and behavioral. No matter how exhaustively we study immediate causes of behavior, we will never achieve a complete and accurate understanding of behavioral phenomena unless we also try to describe and explain the growth changes in individuals, which continue from conception to death. As Chapter 1 noted, developmental influences help to define and constrain the immediate environmental stimuli to which an individual will respond. As humans we are aware of the dramatic physical, intellectual, emotional, and social changes we undergo throughout life as part of our growth and development. These changes normally contribute to our ability to continually adjust to environmental conditions. The same is true of the influence of development on the adjustments of nonhuman species to their environments.

It is the task of **developmental psychology** to chart and attempt to explain changes in behavior that are related to development. Understanding development is important in its own right, and crucial for a complete understanding of behavior. And because development is biological, as well as behavioral, it is not surprising that the growing field of developmental psychology is heavily dependent upon knowledge from other disciplines. As LaBarba (1981) says, "Increasing awareness of research findings in developmental biology, developmental genetics, developmental neurophysiology, and developmental medicine has spurred the growth of developmental psychology. More important, perhaps, is the growing awareness that the biological, medical, and behavioral sciences must ultimately focus on developmental phenomena so as to achieve a true understanding of human behavior" (p. 3).

Developmental Research Methods

Researchers studying development want to learn how behavior changes with age or time. Does memory improve between the preschool and school years? Does it decline in adulthood? Do personality traits such as dependency, aggression, or intelligence remain fairly stable from infancy on? In what ways does a two-year-old child's language differ from that of a four-year-old? In order to answer such questions researchers have devised special applications of the research methods discussed in Chapter 3. Basically there are two approaches to the study of development: longitudinal and cross-sectional.

The Longitudinal Approach

Longitudinal research involves observing the same group of subjects several times during their lives. For example, if we want to know whether memory declines during adulthood, we might give a group of university students who average twenty years of age a test of memory span. We might decide to test them every five years until they reach the age of sixty-five—a total of ten memory tests. By doing this we could determine whether the group's average memory performance remained stable or changed systematically with increasing age.

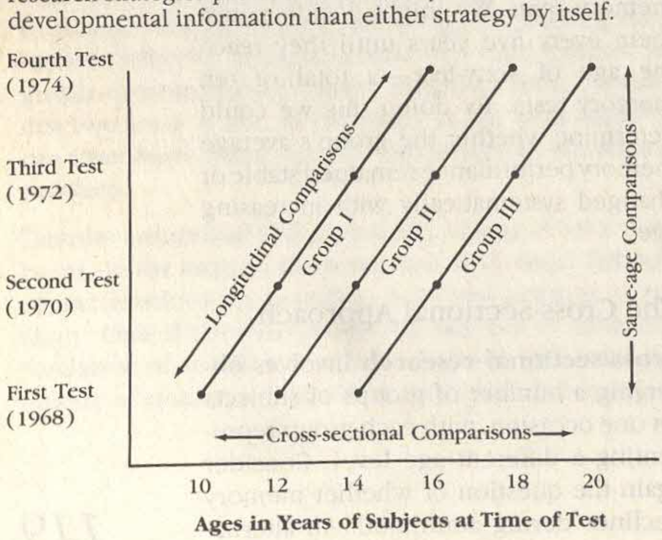
The Cross-Sectional Approach

Cross-sectional research involves observing a number of groups of subjects on one occasion, with each group representing a different age level. Consider again the question of whether memory declines during adulthood. An alternative to testing the same group of subjects every five years for a period of forty-five years would be to observe ten groups of subjects: group 1 made up of twenty-year-olds, group 2, of twenty-five-year-olds, and so on, up to group 10, of sixty-five-year-olds. This approach would permit an immediate comparison of memory performance among the various age groups.

Evaluating Longitudinal and Cross-Sectional Methods

Because the longitudinal approach allows us to track behaviors in the *same* individuals over time, it is well suited for detecting developmental stability or variation in behavior both within and among individuals. Of course, the cross-sectional approach does neither of these things, because we observe *different* individuals on a single occasion.

FIGURE 6.1 Illustration of longitudinal and cross-sectional research strategies used in testing three groups of children. The average ages of Groups I, II, and III at the time of the first test (1968) were 10, 12, and 14 years, respectively. The groups were then retested in 1970, 1972, and 1974. Note that it is possible to have an immediate cross-sectional comparison for ages 10, 12, and 14 at the time of the first test. Longitudinal comparisons within each group are also possible: Group I at ages 10, 12, 14, 16; Group II at ages 12, 14, 16, 18; and Group III at ages 14, 16, 18, 20. Finally, it is possible to compare groups of the same age at different test times. Combinations of longitudinal and cross-sectional research strategies provide considerably more developmental information than either strategy by itself.



Although the longitudinal approach offers more precision than the cross-sectional approach, it has certain disadvantages. Longitudinal studies are costly in terms of time and money; they do not yield meaningful data immediately; subjects often drop out before studies are completed; and the methods of research and data analysis the study starts out with may become outdated, even within a few years. In addition, it is difficult to untangle effects associated with development from those associated with repeated testing of subjects. For example, would improvement in memory performance in a group of children between the ages of four and seven reflect a developmental process, or the "practice" these children received on memory tests? Cross-sectional studies do not have these disadvantages, but they are unable to assess developmental change *within* individuals.

There is one difficulty that neither of these approaches handles—the problem of *generational* effects. During the twentieth century we have witnessed many technological and cultural changes the world over, some of them drastic. Children growing up in the 1920s experienced a very different environment than did children growing up in the 1960s and '70s, for example. In the 1920s there were fewer automobiles and airplanes, less urbanization, no threat of nuclear holocaust, no television sets, restricted opportunities for postsecondary education, poorer nutrition, no antibiotics, poorer prenatal care, more rigid moral standards, less exposure to violence and drugs, and a more closely knit family structure. As a result, longitudinal *or* cross-sectional studies carried out in the 1920s might reveal very different developmental phenomena than would such studies conducted during the 1960s and '70s, even if both sets of studies were investigating the same behaviors.

More and more developmental scientists are using sophisticated *combinations* of cross-sectional and *short-term* longitudinal studies (Figure 6.1). These combinations provide some immediate data because of the cross-sectional component; they do not become excessively costly, because of the short-term nature of the longitudinal component; and, to a certain extent, they are capable of assessing both the effects of repeated testing and generational effects.

One caution is in order. We cannot conclude that age or time *causes* the behavioral changes or differences we observe in longitudinal or cross-sectional studies. To say that many adolescents are rebellious because they are thirteen years old or that many adults experience a "midlife crisis" because they are in their middle years explains nothing. One major reason is that age is not a very precise variable. Rather, we need to identify the physical and psychological variables that change with age and influence the behavioral change we see.

Evolutionary Influences on Development

Human development encompasses the longest period of immaturity of any species in existence today. It relies heavily on learning to bring about socialization, the process by which an individual acquires information that is useful or necessary for getting along in a particular group or culture.

Why the long period of immaturity? Why the heavy reliance upon learning? What accounts for the particular pattern of developmental milestones that characterizes us as a species? Answers to such questions are rather speculative, but consideration and observation of what various developmental characteristics allow us to do, coupled with knowledge of evolutionary history, provides some clues. For example, it seems quite plausible that a brain that is large relative to total body weight is necessary to support language and complex verbal and spatial reasoning skills (Jerison, 1973). Such skills would have bestowed a gigantic selective advantage upon the prehumans and early humans who possessed them, in the form of more effective cooperative hunting and gathering, evasion of predators, and maintenance of social order. Perhaps these skills even increased their ability to attract mates and socialize offspring. More simply, the larger the brain-to-body weight ratio, the better the chance of a hominid surviving, reproducing, and ensuring its offspring's survival and reproduction.

But why should our predecessors have *needed* a large brain? Anthropologists hypothesize that the answer may lie in prehuman and early human's uniquely *bipedal* nature. Although it freed the hands for behaviors other than locomotion (for example, tool construction and use), nevertheless their upright stance must have placed our ancestors at a real disadvantage compared to other animals.

> . . . Australopithecines were bipeds, as can be seen from the anatomy of the pelvis and leg, and the placement of the skull. Admittedly, it was fashionable in a generation gone by to envision the Palaeolithic hunter bounding across the grasslands on his long, straight legs, as

A member of a contemporary hunter-gatherer tribe. Hunting and gathering have been the major survival activities of humans and the hominid line. Survival as hunter-gatherers was likely dependent on the evolution of a relatively large and sophisticated brain capable of outwitting predators and prey, locating sources of food and water, communicating at a distance, learning and devising rules for maintaining social cohesion and order, and transmitting learned information to offspring.

> though bipedalism were somehow the most efficient and "best" possible way of getting around. To anyone who may still harbor the lingering residue of such an illusion, I suggest that you seriously consider the vision summoned up by an irate adult *Homo sapiens* in hot pursuit of a thoroughly frightened *Felis domesticus* (house cat). As a mechanism for high-speed locomotor efficiency, hominid bipedalism is ludicrous. Obviously a creature which cannot even catch a small cat has even less chance of getting away from a large one, and it is certain that such felines as leopards and lions, as well as a variety of pack-hunting canines, must have posed a constant threat to the survival of any savannah-dwelling primate during the Pleistocene (Brace, 1967, p. 61).

So what does all this have to do with human development? Just this: large brains take a longer period of time for development than small brains. Selection for adults with increasingly larger and "smarter" brains may have necessitated selection for a longer period of immaturity to support the development of the brain (Dobzhansky, Ayala, Stebbins, & Valentine, 1977). Brain growth beyond a certain point could not be accomplished within the womb because it would have required a substantially longer period of pregnancy, and even greater increases in the size of the uterus, birth canal, and supporting pelvic structures than had occurred already. The more feasible evolutionary route to a larger brain, apparently, was to bear young with fairly immature nervous systems, which would need to undergo much of their development *postnatally* — after birth. It is interesting in this regard to note that our closest living biological relatives, chimpanzees, have a much smaller brain than ours as adults. Yet gestation time for chimps is approximately thirty-three weeks, and for humans approximately thirty-eight weeks — not much difference. There *is* a major difference, however, in the level of maturity of the brain at birth. The chimpanzee brain is about one-half its adult size at birth, while the human brain is only one-fourth its adult size (Schultz, 1968).

It seems clear that our long period of immaturity was selectively advantageous. The hominids with genes for constructing larger and more complex brains, who, therefore, required longer periods of development, were more likely to survive the challenges facing early hunter-gatherer societies and pass on such genes to subsequent generations. Thus the *why* of human development helps us to understand the length of time it takes us to reach sexual maturity, compared to the developmental timetables of other species.

Maturation, Experience, and Development

With few exceptions, developmental scientists, including developmental psychologists, have very little information about how specific genes interact with specific environments to produce specific developmental outcomes. (One of the exceptions was mentioned in Chapter 5, where we discussed phenylketonuria.)

Although there are few instances where a specific genetic-environmental interplay that contributes to development can be isolated, we can describe the *general* ways these forces shape development.

Genetic factors influence development through the process of maturation. When developmental scientists speak of maturation, they are referring only to a hereditary process that affects development by acting on *physical* structures. Environmental factors, on the other hand, influence development through *experience.* Development is the product of the dynamic interplay between maturation and experience.

Maturation

Maturation refers to the anatomical and physiological development of the organism, which proceeds from conception on and includes *quantitative* as well as *qualitative* change. Quantitative change is what many people would refer to as, simply, *growth:* cells, tissues, organs, and other structures increase or decrease in number, size, shape, volume, and so forth. Examples of quantitative change in maturation include the rapid proliferation of cells that takes place in the human embryo during the first month of life, the increase in muscle and bone size throughout childhood, the increase in breast size in adolescent girls, and the decrease in the amount of subcutaneous fat in boys following adolescence.

But maturation also involves changes that are more than the addition or subtraction of units of growth—changes that are qualitative, and that represent *reorganizations* of existing anatomical and physiological characteristics. Some examples of qualitative changes are the differentiation of new organs from a mass of cells during embryonic and fetal development, the development of neurological and motor control over the anal sphincter toward the end of the second year of life, and the complex of changes in the female reproductive system just prior to and during adolescence that make conception possible.

The quantitative and qualitative changes that characterize maturation are under rather strict genetic control, and in a normal environment will take place fairly automatically according to a genetically coded timetable. There is a good deal of evidence that highlights the automatic nature of maturation and, in some instances, its relative freedom from certain environmental influences. A widely cited cross-cultural study of child-rearing practices among the Hopi Indians of Arizona (Dennis & Dennis, 1940) revealed that restricting infants' movements does not delay the onset of walking. Shortly after birth, Hopi babies are wrapped in blankets and bound to cradle boards; little movement is possible. There is little time off the cradle board, although there is some, and there is a good deal of social stimulation from parents. This cradling practice continues for six to twelve months, and yet, remarkably, the Hopi children studied by Dennis and Dennis differed in the average age at which they started walking by only two days from children whose movements had not been restricted. This finding suggests that there is a strong maturational component in the development of walking, and that the onset of walking is not dependent on a great deal of movement or on trial-and-error learning. The development of motor skills other than walking also seems to depend heavily on maturation. In some studies in which infants have been given varying amounts of physical motor training, these manipulations appear to make little difference in when various motor skills emerge (Dennis & Dennis, 1941; Gesell & Thompson, 1929; McGraw, 1935, 1939).

A Hopi Indian mother with her infant strapped to a cradleboard.

In many cases, especially during infancy, childhood, and adolescence, maturation is a determining factor in the emergence of new behaviors. Infants cannot learn to walk, run, climb, or talk until there is sufficient maturation of the brain and neuromuscular system. Children do not learn to read until neural structure and function underlying visual perception and visual and verbal memory have matured sufficiently. And the ability to understand and solve the sort of abstract problems found in mathematics, the sciences, and philosophy is most likely dependent upon the attainment of a high level of brain maturation.

None of the foregoing is meant to imply that the environment is unimpor-

Most children *learn* proper toileting behaviors. However, sufficient *maturation* of neuromuscular skills is necessary before toilet training is effective.

tant to the maturational process, or that some kinds of environmental stimuli cannot affect the rate or level of maturation. We know, for example, that human height is under maturational and, therefore, genetic control. We also know that malnutrition, an environmental factor, can reduce the growth rate and limit the eventual height attained as an adult. We will examine additional examples of environmental effects below.

Experience

Experience refers to the encounters an organism has with its external and internal environment, encounters that can have profound effects on maturation and on behavior. In the context of developmental psychology, experience is characterized broadly, ranging from the physiological effects of maternal malnutrition on a developing embryo to the psychological effects of exposing a young child to repeated acts of violence on television.

Some kinds of environmental experiences that affect development are shared by nearly all members of a species or class of animals. For example, genetically male fetuses or newborns of all mammalian species will not develop normal male physical sexual characteristics unless the male hormone, testosterone, is produced at the right time. Note here the difficulty in separating effects of maturation and experience. Production of testosterone is under genetic control — maturation. But once produced, testosterone represents an important environmental experience for the organism.

Another example of a normal environmental experience typically shared by members of a species is that of parental caregiving to the young. Proper parenting behaviors, including feeding, providing bodily contact and warmth, cleaning and grooming, communication, and defending, are important elements in the survival and normal development of the young of many species (Cairns, 1979).

Assessing the Effects of Experience Experimental and nonexperimental studies involving both nonhuman and human subjects have shown that certain kinds of *alterations* in environmental experience can have a significant impact on the course of development. Basically, there are two major ways to assess the importance of experience to the developmental process. One involves comparisons of animals or humans deprived of certain kinds of experience with those not deprived. If development proceeds differently for each group — for example, if the deprived group shows retarded or impaired development — then the experience that has been denied is deemed to be important to development. Of course, cause-effect inferences concerning experience and development can be made with confidence only if the deprivation was *experimentally* manipulated. Because of ethical considerations, deprivation experiments are done only with nonhuman subjects.

The other major way to examine the relation between experience and development is to compare animals or humans given extra or special experiences — enrichment — with those who have received only the normal amount or kind of experience. If the enriched group shows accelerated or improved development, then the enrichment is deemed important to producing optimal development. The use of human subjects in enrichment experiments often can be justified, because the nonenriched group is not being deprived of normal environmental stimulation. The enriched group is simply getting more stimulation, or a different kind of stimulation.

Several animal studies carried out over the years have demonstrated the importance of a variety of experiences in promoting various aspects of development, including sensory and perceptual development and social development. For example Austin Riesen, in a series of studies dating from the late 1940s, showed that *visual* experience is important for the normal maturation of the visual sensory system in various nonhuman primates and in kittens. The earliest of Riesen's studies demonstrated that infant chimpanzees raised in total darkness from birth to sixteen months of age developed serious visual-perceptual deficiencies. In fact, examination of the eyes of light-deprived animals revealed impairment in the development of the retina, the portion of the eye containing light-sensitive cells. Further studies examined the effects of partial deprivation of visual sensory stimulation by equipping monkeys, chimps, and kittens with translucent goggles for one to three months after birth, depending on the species. These goggles allowed the animals to see only diffuse light and, therefore, no features that would define shapes and patterns. Although animals so deprived could make elementary discriminations involving color, brightness, and size when tested following the deprivation period, they showed deficits in distinguishing certain forms, perceiving depth, and detecting moving visual stimuli (Riesen, 1965).

More recent studies of the effects of visual experience on visual sensory and perceptual development have confirmed and extended Riesen's findings. In some of these investigations researchers have studied the activity of individual nerve cells in the visual cortex of the brain. In kittens that have not been deprived of normal visual stimulation, different vertically arranged groups of visual nerve cells, called **cortical columns,** respond to different visual stimuli (Hubel & Wiesel, 1959). For example, if a kitten views a straight line presented vertically, maximal neural activity in one group of visual cortex nerve cells can be observed. But if the line is presented in a different orientation, a different group of nerve cells responds maximally. This differing neural responsiveness to different line orientations undoubtedly plays a role in enabling the kitten to perceive the difference between the two orientations. But what happens when kittens are deprived of normal visual stimulation early in life? In kittens exposed to a single visual pattern and deprived of other visual experiences, nerve cells in certain cortical columns do not develop normal responsiveness. For example, kittens exposed only to vertical lines from birth through four months of age show normal cortical column responses to vertical stimuli but not to horizontal ones. Kittens who have seen only horizontal lines for the same time period show the opposite effect: cortical columns respond normally to horizontal but not to vertical stimuli (Figure 6.2). It seems that visual experience with specific shapes and orientations is necessary for the brain to develop and maintain normal responsiveness to such stimuli (Blakemore, 1974). Some studies have even shown that there is a critical period for these effects in kittens. For example, kittens' cortical column responsiveness to lines of differing orientations appears to develop between three and fourteen weeks of age. It seems that after this time, the critical period, these groups of cells can-

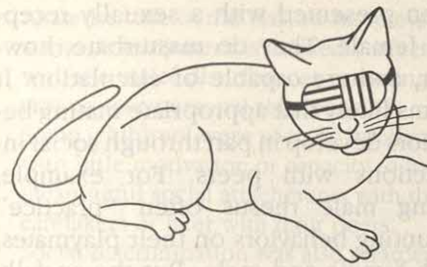


FIGURE 6.2 Kitten wearing goggles that expose one eye to a pattern of vertical stripes and the other to horizontal stripes. Such experiments have shown that when the goggles are removed after a critical period of exposure during the kittens' development, the cells of the visual cortex tend to "recognize" only those patterns to which they have previously responded. That is, the cortical cells that respond to stimulation of the horizontally shaded eye are most likely to respond to horizontal patterns. The cortical cells associated with the other eye are most likely to respond to vertical patterns.

not be modified further by visual experience (Blakemore, 1974).

Are there any human parallels to these animal data to suggest that visual experience is important in the development of our visual sensory and perceptual systems? Perhaps the closest we can come is to examine the cases of people blind from birth because of congenital cataracts over the eyes, which impair vision to varying degrees. Many of these individuals have had their cataracts removed later in life. The results are instructive:

> These patients, who have passed all their lives in near-blindness, ranging from the bare ability to tell day from night to some ability to distinguish colors and localize light, invariably report an immediate awareness of a change after a successful operation. They begin at once to distinguish differences in the parts of the visual field, although they cannot identify an object or describe its shape. After a few days practice they can name colors. From this point on progress is slow, often highly discouraging, and some patients never get beyond the ability to distinguish brightness and color. Others, over a period of months and even years, develop the ability to identify simple geometric figures, read letters and numbers and, in rare cases, to identify complex patterns such as words, outline drawings and faces. During their efforts to improve their visual skill the patients go through a long period of picking out elements in an object and inferring the nature of the object from these elements—often erroneously. For example, a child of 12, some months after her operation, is reported by her doctor to have pointed to a picture and called it "a camel, because it has a hump." What she identified as a hump was the dorsal fin of a fish (Riesen, 1973, p. 63).

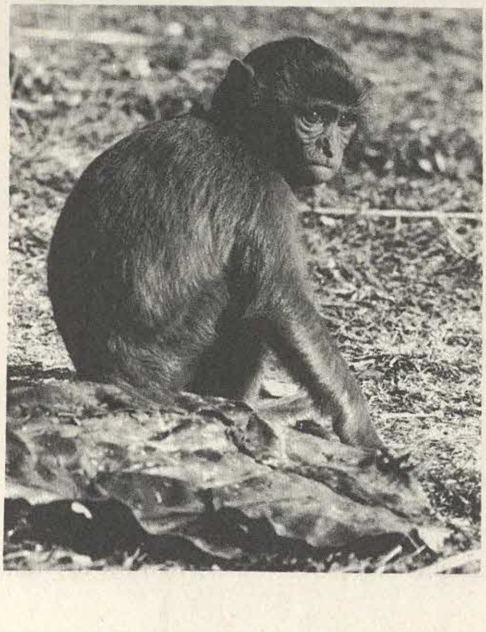
This pattern of visual recovery, ranging from little to incomplete, is similar to that reported by Riesen for chimps following experimental deprivation of patterned visual stimulation.

The studies we have presented thus far relate restricted environmental experience to sensory and perceptual development. There are also many findings that underscore the importance of experience in other aspects of development. Several investigators have reported short-term as well as long-lasting detrimental effects on *social* development and behavior when individuals are deprived of social experience. The work of Harry and Margaret Harlow and their associates is perhaps the most systematic inquiry into the effects of social deprivation. The Harlows and others have found that rhesus monkeys taken from their mothers at birth and isolated in cages develop varying degrees of personal-social abnormalities. Although little impairment takes place with up to three months of social isolation, longer periods are associated with maladaptive behavior and development. Monkeys isolated from birth for six to twelve months, and tested at approximately one year of age, show little movement; little or no approach and exploration in the presence of novel objects, animals, or people; a reduction or absence of social play; inappropriate aggression; and a whole host of so-called autistic responses that resemble the behavior patterns of severely disturbed human mental patients, such as extreme withdrawal, self-clasping, rocking, self-biting and self-sucking, and self-directed aggression (Cross & Harlow, 1965; Harlow & Harlow, 1962).

Rhesus monkeys isolated for long periods of time often are sexually inadequate and lack proper parenting skills. Adult males reared as isolates act as though they do not know what to do when presented with a sexually receptive female. They do masturbate, however, and are capable of ejaculation. It seems likely that appropriate mating behaviors develop in part through social interactions with peers. For example, young male rhesus often "practice" mounting behaviors on their playmates, both female and male. But the socially deprived rhesus misses out on these important socializing experiences. Isolation apparently has less severe effects on female sexual behavior, but profound effects on female parenting behaviors. In general, such females make poor mothers: they don't allow their infants to cling to their ventral surface, the normal position for clinging and nursing; they reject their infants when they try to nurse; and they often physically abuse their infants, sitting on them and biting and striking them (Harlow, 1965; Missakian, 1969; Suomi & Harlow, 1971).

It is difficult to imagine examples of human child rearing that would parallel such extreme deprivation. Nevertheless, there are instances of reduced human social stimulation that sometimes are associated with developmental impairments. Some institutional settings, such as orphanages and hospitals, have produced rearing conditions in which children were totally or partially isolated. These children had many caretakers (often indifferent) instead of one set of loving parents, and in some instances they were not allowed to play with other children or toys. Such conditions were much more prominent in institutions in existence thirty or forty years ago than they are today. However, they have not been totally eliminated. Hetherington and Parke (1979) present an informative summary of behavioral effects observed in children reared in certain depriving institutional settings.

Rhesus monkeys such as the one pictured here were used as subjects in the research on social isolation conducted by the Harlows and their co-workers.



> As in the case of the Harlow monkeys, social development is markedly affected, with the major disturbances centering around interpersonal relationships. . . . Some [children] were socially indifferent, with little motivation or capacity to form meaningful social attachments with their caretakers or later with their peers. Social discrimination was also retarded; institutionalized infants often show similar reactions to both familiar caretakers and total strangers. . . . some children show a second pattern . . . characterized by a seemingly insatiable desire for individual social attention and affection. . . . even as adolescents, many institutionalized children continue to show social deficiencies in the form of heightened aggression, impulsivity, and antisocial behavior. . . . In addition, bizarre motor patterns similar to Harlow's "rocking and huddling" monkeys have been reported (p. 162).

Studies of the effects of restricted sensory and social experiences clearly indicate the importance of particular experiences for the maturational process, and for the development of behavior in general. But a few words of caution concerning the interpretation of deprivation studies are in order. First, it is not always clear from these studies exactly what aspect of the deprivation is responsible for the observed behavioral effects, and neither is it clear precisely how such effects are mediated. For example, in the institutionalization studies with humans, and even in many of the social isolation experiments with monkeys, the organism is deprived of both social and sensory experiences. Although there is suggestive evidence that *both* kinds of experience are important for normal development, the critical amounts and kinds needed for optimal development have yet to be determined. Perhaps more important, we still do not know precisely how various physiological structures and functions are affected by the presence or absence of social stimulation.

It is also worth noting that there are differences among individuals within a species, and among members of different species, in reacting to the effects of restricted experience. A few children reared in seemingly impoverished settings somehow manage not to show the adverse effects noted by Hetherington and Parke. Rhesus monkeys also show individual differences in behavioral deficits associated with social isolation. And there are differences between species in response to the stress of social isolation. Sackett, Holm, and Ruppenthal (1976) found that pigtail macaques — monkeys closely related to rhesus macaques — are more passive, less aggressive, and more socially responsive than rhesus, regardless of rearing condition (total isolation for seven to eight months versus normally reared). To be sure, social isolation does have an effect on the behavior of pigtails, but it is much less extensive than the effect on rhesus. These individual and species differences suggest that genetic and perhaps prenatal biological factors must be taken into account when evaluating the impact of various experiences on development. Certain individuals, and species, may be more vulnerable biologically than others to early social isolation.

One final caution concerning *experimental* deprivation studies: the amount and kind of environmental restriction imposed on the monkeys in social isolation would almost certainly never be encountered by monkeys — or humans — in their natural environments. This makes it problematic not only to generalize from the monkey studies to humans, but also to infer that rhesus monkeys or humans are extremely susceptible to environmental effects. As Alcock (1975) explains, the experiments conducted by Harlow and Harlow,

> while showing the importance of early experience for behavioral development, also demonstrate effects opposite to the ones being investigated. They show how difficult it is to alter the course of behavioral development through environmental manipulations. . . . no animal in the history of the species has had to cope with the bizarre environmental situations devised by the Harlows and other researchers in this field. It is not surprising that the animals' developmental systems break down under these conditions. What is surprising and revealing is that otherwise totally isolated infants will develop essentially normal behavior if they are introduced into a cage with three other infants for just 15 MINUTES each day. . . . despite the barren existence of isolate infants, a few moments of playtime a day is sufficient to counteract the effects of extreme deprivation. . . .
>
> What this research really shows is that the rhesus genetic-developmental system is beautifully and powerfully protected AGAINST environmental disruptions. . . . The genetic program can make do with only a tiny fraction of the normal experiences that rhesus babies usually have and still promote fairly complete behavioral development (pp. 61–62).

We have spent a good deal of time outlining the roles of maturation and experience in behavioral development because of the enormous amount of misunderstanding and controversy that has surrounded these topics. The misunderstanding has been generated by attempts to determine which is *more* important in structuring development, maturation or experience. If you have read Chapter 2, you will recognize this question as a version of the heredity-versus-environment, nature-versus-nurture issue. In fact, concern about the heredity-environment problem has always been in the forefront of developmental psychology. By now it should be clear that *both* maturation and experience, and their dynamic interplay, are essential to development. How experience affects development will depend on the organism's maturational level. Likewise, the experiences an organism has may well affect further maturation.

Prenatal Development

The topic of abortion engendered intense controversy during the 1970s, and the debate continues today. One of the key issues in this controversy involves when a human life actually begins. Of course, the answer to this question depends entirely on how life is defined. The concept of life involves far more than the biological level of analysis; it is also addressed from philosophical and theological perspectives. Therefore, it is not possible to provide a *scientific* answer that speaks to all three levels of analysis, and so the issues surrounding abortion are not likely to be resolved by polling panels of scientists, as was done in the early 1980s by the U.S. Congress. What we *can* say scientifically, however, is that the developmental processes which underlie metabolism and the proliferation of cells in the fertilized egg are active immediately after conception, and that the first skeletal motor responses appear about seven weeks later. Growth occurs rapidly, and in an extremely complex manner, so that by the age of twenty-eight weeks the structures and functions of the human fetus are sufficiently well developed to permit survival in the event of premature delivery.

Stages of Prenatal Development

Human prenatal development is divided into three phases: the period of the **ovum,** the period of the **embryo,** and the period of the **fetus.** The entire process of prenatal development is accomplished in 266 days on the average in humans, but growth is most rapid during the early phases of development. It is truly amazing that the fertilized egg, the zygote, starts out at about 0.14 millimeters in diameter, weighing less than 1 milligram, and reaches a length of about 500 millimeters and a weight of approximately 3,000 grams at birth. The embryo is simply a mass of undifferentiated cells at one week, but it appears distinctively human and can make certain reflexive movements by eight weeks; at twenty-eight weeks it can survive premature birth. Clearly, development is exceedingly rapid and complex during this time. The timing of prenatal development is strongly tied to genetic instructions and hormonal events, and several external environmental factors can affect the developing embryo or fetus.

Period of the Ovum The first stage of human prenatal development spans the first two weeks following fertilization of the ovum. The stage is characterized mainly by rapid mitosis and some differentiation. By the third day, what started out as a single fertilized ovum is now a solid cluster of cells called the **morula.** By the fourth day a cavity has developed in the morula in preparation for what will later be the connection to the placenta, and the morula is now called a **blastocyst.** By the sixth day the blastocyst is migrating down the fallopian tube, and its tendrils begin to penetrate the blood vessels in the wall of the uterus (Figure 6.3). This is the beginning of the placental connection, although the **placenta,** the organ that conveys nutrients from mother to embryo and removes waste materials, does not become functional until the next stage.

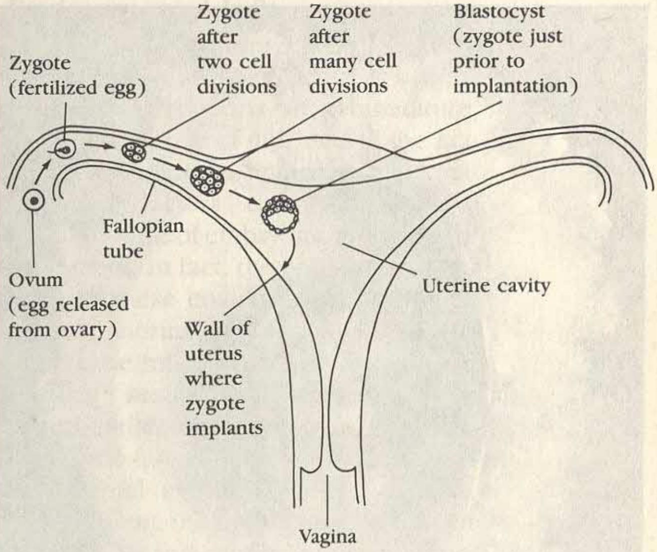
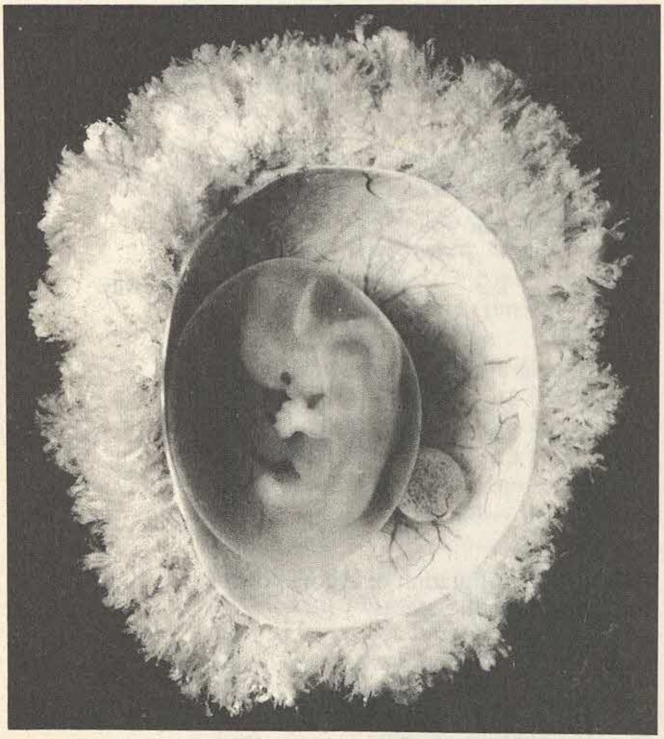

Zygote (fertilized egg)
Zygote after two cell divisions
Zygote after many cell divisions
Blastocyst (zygote just prior to implantation)
Fallopian tube
Ovum (egg released from ovary)
Wall of uterus where zygote implants
Uterine cavity
Vagina

FIGURE 6.3 Migration of zygote down fallopian tube and implantation in the uterus.

Period of the Embryo This stage occurs in the third through the eighth weeks and is characterized mainly by the rapid development and differentiation of various mammalian characteristics, such as a head, tail, gill arches, lens of the eye, limbs, parts of the lips, primitive (beating) heart, primitive brain, lungs, thyroid, liver, gall bladder, and pancreas. Throughout most of this stage the human embryo looks much like the embryos of many other species (see Figure 4.3), and does not begin to take on distinctly human characteristics until the end of the embryonic period.



A human embryo during an early phase of prenatal development.

Three layers of tissue, the **endoderm,** the **ectoderm,** and the **mesoderm,** differentiate and begin to develop into the various tissues, organs, and systems. The endoderm gives rise to the gastrointestinal tract, trachea, bronchia, lungs, pancreas, liver, glands, and other internal organs. The ectoderm develops into the outer layer of skin, skin glands, sensory cells, fingernails, hair, parts of the teeth, and nervous system. The mesoderm gives rise to the inner layer of skin, the skeleton, skeletal muscles, and the excretory and circulatory systems.

It is also during this stage that the **amniotic sac** that surrounds and protects the embryo develops. The amniotic sac contains **amniotic fluid,** the liquid medium that will protect the embryo from physical trauma for the remainder of its prenatal existence. The placenta, derived from the tendrils implanted in the wall of the uterus, becomes functional about the fourth week of life, when the **umbilical cord** is established between the placenta and the embryo. The cord is composed of blood vessels that carry blood to and from the embryo, so that there is metabolic exchange between mother and embryo. Note that there is no direct exchange of blood between embryo and mother. Membranes within the placenta prevent this; they allow nutrients and certain other substances to pass from the mother's blood to that of the fetus, and waste products to pass from fetal blood to the bloodstream of mother, but blood itself does not cross the membrane.

Period of the Fetus The final stage of prenatal life spans the period from eight weeks to approximately thirty-eight weeks. It is characterized mainly by growth and differentiation of detail, rather than by further gross structural reorganizations. The fetus increases in mass, its features become more finely differentiated and human, neural-muscular systems develop rapidly, and fetal movement becomes a prominent feature.

The first behavior occurs at about eight weeks of age. It consists of a reflexive turn of the head, neck, and trunk when the mouth-nose area is lightly stimulated. This turning movement is directed away from the side being stimulated, and appears to function as an avoidance reaction. Many other reflexes emerge over the course of the fetal period, including grasping and mouth opening in response to stimulation of the palm of the hand, foot withdrawal to touching of the sole of the foot, a gag reflex to stimulation of the back of the tongue, fanning of the toes to touching of the sole of the foot, and knee-jerk, Achilles tendon, and sucking reflexes.

Spontaneous, uncoordinated body movements occur at about nine to nine and a half weeks; no apparent stimulus evokes them. Spontaneous brain wave activity is apparent at ten to eleven weeks, and respiratory activity at thirteen weeks. The first spontaneous movement of the entire fetus occurs at about fourteen weeks, and this is about the time fetal movement becomes discernible to the mother. Hiccups have been observed by twenty to twenty-four weeks, and crying by twenty-eight weeks. By twenty-eight weeks the fetus is capable of sensing certain tastes, and can see and hear to a limited extent. Even before this time, by about twenty weeks, the fetus shows evidence of *biological rhythms:*

> The earliest observed rhythms in human fetal behavior have been found in the fifth month by continuous recording from sensors placed on the mother's abdomen during her sleep. . . . Fetal movements were not evenly distributed throughout the night but showed an irregular alteration of peaks and troughs. No systematic trends in the level of this activity or its periodicity were observed over the 4-month period to term, although the quality of the movements altered slowly from sudden jerks to more sustained activity. By sensitive computer techniques, two basic cycles were extracted that seemed to underlie these apparently irregular fluctuations: one recurring at about 40 minutes and another, weaker one at 96 minutes. . . .
>
> This, then, is the first evidence of temporal organization imposed on fetal behavior. Thus begins a form of organization that will underlie and influence all behavior in the months and years to come (Hofer, 1981, p. 101).

Environmental Influences

Certainly events in the intrauterine environment, such as the presence of various hormones, variations in temperature, and the presence of nutrients in the maternal bloodstream, interplay with maturational factors to determine the normal course of embryonic and fetal development. In fact, the proper timing of some of these environmental events is crucial to normal development, as in the case of the influence of testosterone on physical sexual development, mentioned earlier in the chapter. Although there is no question that intrauterine environmental events influence prenatal development, the importance of some of these events and conditions is seen most readily when something goes wrong in the course of embryonic or fetal development.

Spontaneous abortion, premature birth, and various physical and behavioral abnormalities present in the newborn infant or manifested later in childhood sometimes can be traced to environmental agents in the uterine environment. Environmental factors that bring about mortality or developmental disabilities are called **teratogens.** It is believed that teratogens may account for as much as 75 percent of all mortality and disability that originate during prenatal life; genetic factors and chromosomal anomalies are thought to account for the remaining 25 percent (Wilson, 1972).

Several prenatal environmental circumstances or conditions and their known or suspected teratogenic effects are listed in Table 6.1. It is important to realize that only a few conditions are definitely known to be *causally* related to harmful effects on the embryo or fetus. Our knowledge is based mainly on correlational data obtained from humans and experimental data from nonhumans,

Children whose mothers took the tranquilizer thalidomide during pregnancy sometimes suffered gross deformities of the limbs.

and as we pointed out in Chapter 3, it is impossible to infer causation from correlation. For example, even though positive correlations have been found between level of alcohol consumption reported by pregnant women and low birth weight in their offspring, we cannot conclude from these data that it is the alcohol that *causes* low birth weight. It could be the alcohol, but it could also be poor nutrition (heavy drinkers are often undernourished), or heavy consumption of nicotine, caffeine, or other drugs. Moreover, data from nonhuman subjects, experimental or otherwise, may or may not apply to humans. Consider the following example of mismatch between nonhuman and human findings. The drug thalidomide, a medication for symptoms of morning sickness, was prescribed widely to pregnant women during the 1950s and early '60s. Thalidomide, even in heavy doses, produced no adverse side effects on the women who took it, but sometimes resulted in gross deformities in the limbs of their offspring—for example, limbs missing, with hands and feet attached directly to the torso. Yet while low dosages of thalidomide are toxic to the human embryo or fetus, it takes large amounts to produce similar effects in other species, and many species appear to be immune.

This is not to suggest that nonhuman studies of prenatal teratogens are of little value. They are often very valuable, because they usually involve a great deal more precision and experimental control than we can achieve in human studies, and for this reason their findings can be interpreted more easily. Moreover, when a substance has been found to act as a teratogen in rats, mice, or rabbits, this can serve as a potentially life-saving caution against human consumption of that agent until further research has clarified the matter.

Two final points concerning prenatal environmental influences need to be made. First, these influences do not operate independently of genetic factors. Both fetal and maternal genotypes undoubtedly account for some of the variation we see in the effects of teratogens and other environmental influences. If a group of women is exposed to the same amount of a particular teratogen at the same stage of pregnancy, some offspring will show extreme effects, others no effects, and the rest will vary between these extremes. In other words, pregnant mothers and their fetuses may be genetically predisposed to be more or less vulnerable to the effects of particular prenatal environmental influences.

Our last point concerning prenatal influences involves their *timing*. In gen-

TABLE 6.1 Some Prenatal Environmental Influences Known or Suspected to Be Teratogenic

Environmental Influences	Related Prenatal or Postnatal Effects	Known	Suspected
Maternal age (over 35 years)	Increased risk in offspring of Down's Syndrome, a type of mental retardation		✓*
Poor maternal nutrition	Increased risk of prematurity, inadequate development of the nervous system, learning disorders		✓
Drugs			
Androgen (male hormone)	Masculinization of external genitalia of female fetus	✓	
Folic acid antagonists (Folic acid is a B vitamin)	Abortion	✓	
Thalidomide	Missing limbs; facial malformations; fusing of fingers and toes; digestive, genitourinary, and cardiac malformations	✓	
DES (Diethylstibestrol)	Increased risk in female offspring of vaginal abnormalities and cervical cancer		✓
Maternal addiction to heroin and morphine	Addiction in offspring, prematurity, low birth weight		✓
Cigarettes (maternal and paternal)	Prematurity, low birth weight		✓
Alcohol (maternal and paternal)	Low birth weight and size; metabolic disorders; retarded physical growth; defects of the face, limbs, and cardiovascular system; mental retardation; irritability and hyperactivity		✓
Maternal diseases			
Rubella	Abortion, stillbirth, retarded physical growth, cardiac disorders, cataracts, deafness, mental retardation	✓	
Syphilis	Abortion; blindness; mental retardation; eventual postnatal deterioration of intellectual, speech, and motor abilities	✓	
Radiation	Nervous system defects, retarded physical growth, mental retardation, cancer, genetic mutation	✓	
Maternal emotional disturbance	Abortion, stillbirth, prematurity, pregnancy and labor complications, excessive crying in newborns, colic		✓

* The causative factors related to increasing maternal age are hypothesized to involve changes in ova due to internal biochemical factors or to long-term exposure to radiation, or both.

NOTE: *Known* means that a cause-effect relationship has been definitely established. *Suspected* means that a cause-effect relationship is likely, but has not been definitely established in humans.

eral, it appears that organ systems are most susceptible to environmental influence during times of rapid development. These times are called **critical periods,** a concept derived from embryology. Different organ systems have different times of vulnerability, or different critical periods. For example, parts of the nervous system develop very rapidly during the embryonic stage, while neuromuscular systems do so during the fetal stage. Therefore *when* a teratogen is encountered is important in determining which organ system is affected. Rubella, known as German measles, if contracted by mothers during the first three months of pregnancy, can produce cardiac disorders, cataracts, deafness, and severe mental retardation in the offspring. If this virus is contracted during the second three months of pregnancy, its effects are not nearly so pronounced, and the percentage of offspring showing harmful effects is greatly reduced.

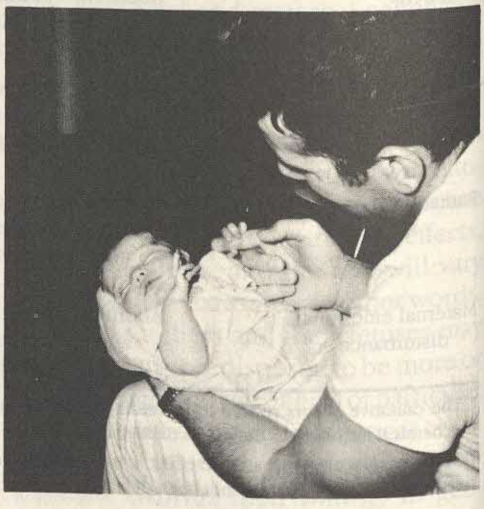
Infancy

The period of human **infancy** covers the first two years of postnatal life. Like the prenatal period, it is characterized by rapid and fascinating developmental accomplishments. In twenty-four months the infant changes from a totally dependent creature with a restricted behavioral repertoire to a confident, walking, talking, playful little explorer. Most of the developmental changes observed in infants are quite regular, and can be seen in children the world over. It would seem that many such changes are largely orchestrated by maturational factors. Yet infants show evidence of a great deal of behavioral flexibility; they can adjust many of their behaviors in response to changing environmental stimuli. In other words, they can learn. In addition, there is a good deal of behavioral variation among infants, which reflects differences in both genetic and environmental factors.

Characterizing the Newborn

The newborn, or **neonate,** is indeed a dependent creature. This is more or less true for neonates of a variety of species, but nowhere is it more apparent than in *Homo sapiens.* The human neonate cannot locomote on its own, cannot coordinate its eyes and hands very well, cannot feed or protect itself, and cannot talk. Left to its own devices it would surely die. But focusing on the helplessness of the newborn can be quite misleading. First, the vast majority of human adults, parents or otherwise, do not leave babies to their own devices. In conjunction with the lengthy period of immaturity that characterizes the young of our species, it seems that we have evolved strong moti-

Newborn babies, although extremely dependent on others for survival, are capable of a surprising number of behavioral skills.



vations for parenting, effectively countering any nonadaptive effects of newborn helplessness. Second, despite its dependency, the newborn has a number of abilities that are quite remarkable. Many parents do not know, and are often surprised to learn, that their newborn children can see, hear, smell, and taste things, and can engage in a variety of behaviors, including taking steps while being supported under the arms, grasping a rod with sufficient strength to support their weight, and even reaching for and grasping objects that are seen.

Whether a newborn reacts to an environmental stimulus, or the degree to which it does so, is dependent in part upon the infant's state at the time. We use the term *state* to refer to the level of alertness or activity shown by the infant. There are three general states that characterize the newborn's behavior—*active sleep, quiet sleep,* and *wakefulness.*

Active sleep is also known as **REM (rapid eye movement) sleep** because it is characterized by rapid eye movements with the eyelids closed. It is termed *active* because of the limb movements, grimacing, irregular and fast breathing, and fluctuations in heart rate and blood pressure that occur in that state. REM sleep in adults is associated with dreaming, but not with the excessive motor activity seen in newborns. We cannot say whether infants also dream during this kind of sleep, let alone what they might dream about. One thing that is striking, however, is that newborn babies spend 50 percent of their sleep in REM sleep, compared with about 20 percent for adults. The other 50 percent involves quiet, non-REM sleep.

The newborn spends about two-thirds of its time sleeping or drowsy. The remaining third of the time is characterized by wakefulness, which consists of *quiet inactivity, waking activity,* and *crying.* During quiet inactivity, a state prized by most parents, the infant is visually attentive, fully awake, breathing evenly, and quiet. This state accounts for little of the newborn's time, however—roughly 11 percent. Waking activity consists of spontaneous and elicited movements of the body. And we all know what the state of crying is, although you may be surprised to find out that there are acoustically distinct patterns of crying. Other than the first cry at birth, the newborn has at least two kinds of cries: the "pain cry" and the "hunger cry" (Wolff, 1969).

Newborn states are under strong internal control. It appears that infants need to spend a certain proportion of every two-to-four-hour period in each state, regardless of existing environmental conditions. Nevertheless, the environment can influence the timing of states and the transitions among them. For example, infants organize their periods of sleep and waking around feeding schedules, a very important feature of their environment. And the environment can also alter a newborn state, as for example when a loud noise wakes an infant from quiet sleep, or when a parent rocks a child and stops its crying (Hofer, 1981).

The significance of these states is not fully understood, but they clearly are more than passive responses to basic needs such as hunger or avoidance of pain. This is indicated by the fact that the various states begin to differentiate prenatally, when there is little delay between experienced needs and satisfaction, and the fact that they occur in rhythmic patterns that are not always tied to biological needs.

Newborn states probably reflect the activities of an immature and rapidly developing nervous system. In addition, they may provide a feedback system that contributes to nervous system maturation. For example, the high level of REM sleep may provide needed stimulation to brain centers that, in turn, help control the development and functioning of the central nervous system (Roffwarg, Muzio, & Dement, 1966).

Behaviors of the Newborn

Many of the behaviors we see in newborn babies are reflexes that can be elicited by specific stimuli. A nipple placed in the baby's mouth elicits sucking; a light shining directly into the baby's eyes elicits a pupillary reflex, the constriction of the pupils; a light touch on the cheek elicits rooting, a head turn in the direction of the stimulus accompanied by mouth opening and attempts to suck. A description of the major reflexes of newborn babies is provided in Table 6.2.

TABLE 6.2 Reflexes Observed in Newborn Babies

Reflex	Stimulus
Pupillary constriction	Bright light shined in eyes
Eye closure	Bright light shined in eyes Tactual stimulation of cornea Tap on bridge of nose
Lip protrusion	Tap on upper lip
Sucking	Insertion of object in mouth
Rooting	Tactual stimulation of cheek
Arm flexure	Extension of forearm to elbow
Palmar grasp	Pressure against palm
Moro (forearms and fingers extended laterally, then returned to midline)	Loss of support Sudden change in head position Loud sound Surprising stimulus
Ankle clonus (toe flexure) (also called the plantar reflex)	Pressure against ball of foot
Babinsky (big toe extends, small toes spread)	Continuous tactual stimulation of sole of foot from toe toward heel
Withdrawal (of foot and leg or other limb)	Painful tactual stimulation
Stepping	Being supported in an upright position with feet touching floor
Swimming	Immersion in water with head supported

Although these behaviors occur when specific stimuli are introduced, some of them, such as grasping and rooting, can also occur spontaneously. Reflexes are rather rigid in nature, but newborns are also capable of more flexible behaviors. Reaching for an object is an example of more flexible behavior, as is visual scanning of a human face.

Newborn Sensory and Perceptual Capacities

It was once thought that newborn babies are bombarded by an array of lights, noises, and other sensations that are meaningless to them. The idea was that a good deal of experience and growth was necessary before infants could perceive or understand their sensations, that is, before they could recognize the features of their environment. We now know that this view is not valid; human neonates show considerable sophistication in making sense of their environment.

We know most about visual sensory and perceptual capacities in infants, and well we should. Vision is the dominant sense for humans and other primates. It appears to be particularly important in the early establishment of affectional bonds between infants and their caregivers. What can newborns react to and perceive visually? The list includes changes in the brightness, form or pattern, and movement of stimuli. Newborns have a relatively fixed focus for objects; they cannot change the shape of the lens of the eye in order to clearly focus objects at distances much closer or further than nineteen centimeters from the face. Interestingly, this is about the same distance a mother's face is from the infant's during nursing. Thus the nineteen-centimeter fixed focus may represent a significant evolutionary adaptation, considering the importance of facial gestures and interactions in establishing a bond between mother and child. Within a newborn's fixed focus, the edges and angles of objects are scanned, and the infant looks longer at complex and social stimuli (such as faces) than at simple or inanimate objects.

Although less is known about the other senses, there have been some intriguing discoveries about hearing, smell, and taste. Newborn sensitivity to sounds seems to be similar to that of adults. They can discriminate among sounds that vary in loudness, pitch, and spatial location, and seem to prefer relatively high-pitched sounds, such as those produced by female adults speaking to them. Perhaps it is no accident that adults of both sexes tend to modulate their voices to higher frequencies when talking to their babies. Some of the most dramatic research involving hearing in newborns has to do with perception of speech. For example, William Condon and Louis Sander have shown that newborns tend to synchronize their limb movements with sound segments of speech (1974). A similar phenomenon is also seen in adults engaging in conversation, but can only be detected by careful film or videotape analysis. It is remarkable that the movements are synchronized as early as two days after birth, and that they are specific to speech. The rhythmic pattern of movements can be elicited by live or tape-recorded speech, and the movements occur even if the infant hears speech in a foreign language, but not in response to isolated vowel or mechanical sounds (Condon & Sander, 1974). Research on newborn hearing strongly suggests that humans are genetically programmed to begin processing sounds at birth or before, especially those that are biologically significant for them—speech sounds. Not only are such sounds perceived and apparently preferred, but newborns can modify their behavior based on the auditory information extracted. For example, a newborn with as little as twelve hours' exposure to its mother's voice will respond as if it prefers her voice over an unfamiliar one (DeCasper & Fifer, 1980).

Little is known about smell and taste in newborns, or in adults for that matter. But it seems clear that each of these senses is functional in the newborn. Neonates can discriminate among a variety of odors, and they tend to turn away from those that are unpleasant. And, as with auditory information, newborns can use olfactory information to modify their behavior. Macfarlane (1975) has demonstrated this by showing that newborns prefer the smell of a used breast pad to one that is not used, and that by ten days of age they can discriminate between their own mother's breast pad and that of another nursing mother. Macfarlane has shown that this discrimination is based on the scent secreted by skin glands surrounding the nipple, called Montgomery's glands, not on the smell of milk.

Taste is often determined by smell, so it is difficult to assess newborn discriminations and preferences based on taste alone. However, there is little doubt that infants perceive sweet and salty tastes, and they can even discriminate between different concentrations of sweet-tasting solutions (Desor, Maller, & Turner, 1973).

It should be clear from consideration of the various reflexes in newborns that touch is a highly developed sensitivity.

Apparently this is the first sensory capacity to emerge during prenatal life, and it is obviously crucial in terms of providing the infant with important information about other people and objects in the environment. It is often assumed that newborns do not experience much pain, and little systematic research has been done on infant pain perception for obvious ethical reasons. Nevertheless, babies do show delayed reactions to stimuli that would definitely produce pain in older children and adults. For example, increases in heart rate and disturbances in sleep patterns have been observed in newborns following circumcision (Macfarlane, 1977).

Physical Growth and Motor Development

The average full-term male newborn is about 500 millimeters (twenty inches) long and weighs approximately 3.4 kilograms (7.5 pounds). Males are slightly longer and heavier than females, and there is much variation in normal birth size and weight.

Physical growth is phenomenally rapid throughout infancy, especially during the first year. By the end of the first year most babies are half again as tall as they were at birth, and they have tripled their birth weight. Growth of different parts of the body proceeds at different rates. For example, the head grows fastest during the prenatal period, attaining approximately 50 percent of its adult size by birth. The trunk grows fastest during the first year of postnatal life, and the legs grow fastest from one year until the onset of puberty.

There are consistent sex differences in physical growth during infancy: girls grow more rapidly than boys on the average, have less muscle tissue and proportionately more fat and less water, and generally are lighter and shorter (Mussen, Conger, & Kagan, 1980).

Both physical growth and motor development—the emergence of skills such as coordinated reaching and grasping, sitting, standing, and walking—proceed generally according to two principles, the cephalocaudal and proximodistal principles of development. The word *cephalocaudal* comes from Greek and Latin roots meaning head and tail, respectively. The **cephalocaudal principle** states that development proceeds sequentially from head to toe. The head and neck regions grow faster and attain more of their normal size earlier than do the trunk and lower extremities. Likewise for motor development: infants gain control over the muscles of the head and neck before those of the arms, and these are under control before those of the legs. Babies can control head movements before they can sit, and they can engage in fairly precise eye-hand coordination in reaching before they can walk.

The word *proximodistal* comes from Latin words for *near* and *distant,* and the **proximodistal principle** states that development also tends to proceed from the center of the body (proximal) to the periphery (distal). That is, growth is more rapid and motor control occurs earlier toward the center of the body. For example, babies achieve control over the movements of neck and shoulders before they can control their forearms and fingers. Likewise, control over the thigh is achieved before control over the foot.

Although there is variation in the timing of motor accomplishments, they occur in a regular sequence even under a wide variety of environmental conditions. (Table 6.3 shows some of the major motor milestones and their times of emergence.) This, together with

TABLE 6.3 Norms for Motor Activity

	Percent of Population Passing by Age			
Motor Activity	25%	50%	75%	90%
Prone, lifts head				0.7 mo.
Prone, head up 45 degrees			1.9 mo.	2.6 mo.
Prone, head up 90 degrees	1.3 mo.	2.2 mo.	2.6 mo.	3.2 mo.
Prone, chest up, arm support	2.0 mo.	3.0 mo.	3.5 mo.	4.3 mo.
Sits—head steady	1.5 mo.	2.9 mo.	3.6 mo.	4.2 mo.
Rolls over	2.3 mo.	2.8 mo.	3.8 mo.	4.7 mo.
Bears some weight on legs	3.4 mo.	4.2 mo.	5.0 mo.	6.3 mo.
Pulls to sit, no head lag	3.0 mo.	4.2 mo.	5.2 mo.	7.7 mo.
Sits without support	4.8 mo.	5.5 mo.	6.5 mo.	7.8 mo.
Stands holding on	5.0 mo.	5.8 mo.	8.5 mo.	10.0 mo.
Pulls self to stand	6.0 mo.	7.6 mo.	9.5 mo.	10.0 mo.
Gets to sitting	6.1 mo.	7.6 mo.	9.3 mo.	11.0 mo.
Stands momentarily	9.1 mo.	9.8 mo.	12.1 mo.	13.0 mo.
Walks holding on furniture	7.3 mo.	9.2 mo.	10.2 mo.	12.7 mo.
Stands alone well	9.8 mo.	11.5 mo.	13.3 mo.	13.9 mo.
Stoops and recovers	10.4 mo.	11.6 mo.	13.2 mo.	14.3 mo.
Walks well	11.3 mo.	12.1 mo.	13.5 mo.	14.3 mo.
Walks backwards	12.4 mo.	14.3 mo.	18.2 mo.	21.5 mo.
Walks up steps	14.0 mo.	17.0 mo.	21.0 mo.	22.0 mo.
Kicks ball forward	15.0 mo.	20.0 mo.	22.3 mo.	2.0 yr.
Throws ball overhand	14.9 mo.	19.8 mo.	22.8 mo.	2.6 yr.
Jumps in place	20.5 mo.	22.3 mo.	2.5 yr.	3.0 yr.
Pedals trike	21.0 mo.	23.9 mo.	2.8 yr.	3.0 yr.
Balances on 1 foot 1 second	21.7 mo.	2.5 yr.	3.0 yr.	3.2 yr.
Broad jump	2.0 yr.	2.8 yr.	3.0 yr.	3.2 yr.
Balances on 1 foot 5 seconds	2.6 yr.	3.2 yr.	3.9 yr.	4.3 yr.
Balances on 1 foot 10 seconds	3.0 yr.	4.5 yr.	5.0 yr.	5.9 yr.
Hops on 1 foot	3.0 yr.	3.4 yr.	4.0 yr.	4.9 yr.
Catches bounced ball	3.5 yr.	3.9 yr.	4.9 yr.	5.5 yr.
Heel-to-toe walk	3.3 yr.	3.6 yr.	4.2 yr.	5.0 yr.
Backward heel-toe	3.9 yr.	4.7 yr.	5.6 yr.	6.3 yr.

SOURCE: Frankenburg & Dodds, 1967, cited in LaBarba, 1981.

much other evidence, suggests that motor development as well as physical growth is under strong genetic control. This does not mean that the environment has little influence on physical growth and motor development. For example, improved nutrition is undoubtedly a major factor contributing to the more rapid growth, and greater height, of children during the last thirty years or so. Also, it is well documented that blind infants achieve most of the major motor milestones later than do those who can see. Apparently visual experience is important for maintaining a normal schedule of motor development.

Cognitive Development

Cognition refers to all of the activities that constitute thinking, including sensing, perceiving, learning and remembering, conceptualizing, reasoning, problem-solving, and imagining. Compared to older children and adults, infants are quite limited in their cognitive accomplishments. We have already seen, however, that newborns possess a good many sensory and perceptual skills. Many of these become elaborated and more sophisticated during the first two years of postnatal life. In addition, infants begin to show clear evidence of memory at a very early point in life, and their ability to retain information for long periods of time increases rapidly during the first year. Finally, children begin to develop concepts during the first two years of life.

Visual Perception The ability to see improves rapidly during infancy due to changes in the eyes themselves and to the infant's increased control over the eyes. There is clear evidence of color vision in infants by two to three months of age (Banks & Salapatek, 1983), and visual *accommodation*—the flattening or bulging of the lens in focusing on objects at varying distances—develops at a rapid pace during the first month of life, and by four months most infants' accommodative ability is equal to that of adults.

Infant **visual acuity** also develops rapidly. Newborns are estimated to have 20/150 vision at best (Gross, 1985) or, more accurately, they would have if they could focus on objects at different distances. This means that at a distance of 20 feet, a newborn could discriminate an object about as well as an adult with normal (20/20) vision could at 20/150 feet. Improvement in visual acuity is most evident during the first six months of life.

The other major developmental change in the visual apparatus that occurs during infancy involves the eyes' ability to converge. *Convergence* occurs when both eyes focus on an object by rotating toward each other in a coordinated fashion. Convergence provides the perceiver with two slightly different "pictures" of an object that are fused together in a single image. This ability is present at about seven weeks of age.

In addition to these rapid physical improvements in the visual system, there are age-related changes in the way infants visually scan their environments, and in the characteristics of stimuli that hold their visual attention. Studies of infant visual scanning have shown that, until the age of about one month, infants scanning geometric stimuli such as triangles and squares spend most of their time looking at the edges and angles of these figures. But by two months of age more time is spent scanning the internal areas of the figures (Salapatek, 1975). This same developmental trend is found when infants scan pictures of adult faces; one-month-olds spend more time on the boundaries of the face, while two-month-olds attend more to internal components, such as the eyes and mouth (Maurer & Salapatek, 1976).

Many studies have addressed the problem of infant preferences for various visual stimulus characteristics. Do some stimulus dimensions maintain infant attention better than others, and are there any notable age changes in infant attentional preferences? The answer to both questions is yes. In general, infants spend more time looking at patterned visual stimuli than at plain ones, and this preference does not seem to change much with age. Other stimulus characteristics such as movement, intensity, and light-dark contrast also seem to interest infants a great deal. One characteristic that shows a developmental shift, in terms of interest level, is novelty. Many investigators have shown that infants six to eight weeks of age prefer to look at familiar stimuli, while infants eight to twelve weeks of age would rather look at novel stimuli (Weizmann, Cohen, & Pratt, 1971; Wetherford & Cohen, 1973). Note that the relationship between various stimulus characteristics and infant visual attention is *not* linear. It is true that attentional responses will increase or be maintained longer as movement, contrast, intensity and other characteristics increase. However, there seems to be a saturation point, and if there is too much of any of these characteristics, attention is lowered. In other words, some stimuli can be *too* intense or *too* novel. The relationship between attention and characteristics that elicit and maintain attention is best described as curvilinear (Figure 6.4).

The scanning and attentional preferences displayed by infants, and the apparent developmental changes some of these preferences undergo, would seem to make a great deal of adaptive sense. It is biologically smart to be tuned in to movement, for example. Initially this may be important in learning to recognize and form a concept of the mother's face, which is often moving across the infant's visual field. As an infant becomes better able to visually track moving stimuli in a smooth and coordinated fashion, this may be rewarding to the parent who notices the baby visually following him or her. Thus, the baby's ability to visually respond to a moving stimulus, and its attraction to the high contrast offered in faces, may provide rewarding signals to the caregiver, who, in turn, becomes even more motivated to take care of the child's basic needs. In a sense, then, infant visual abilities and preferences may serve to entice parents into becoming closer and more effective, thereby contributing to the child's survival. It is per-

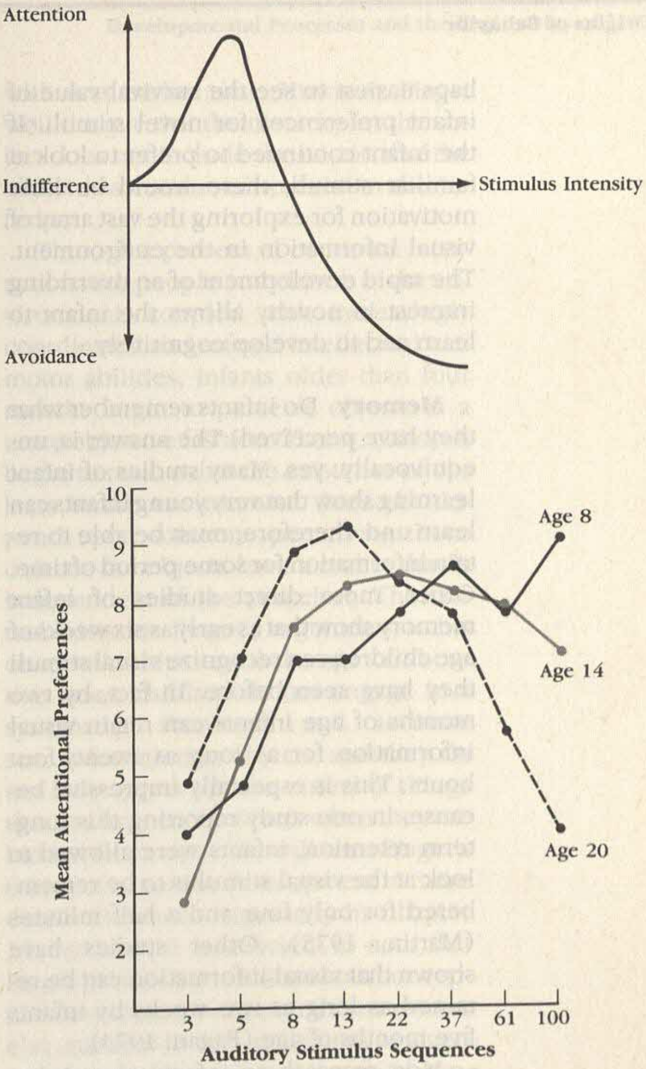


FIGURE 6.4 (*Top*) The idealized relationship between attention and a stimulus that elicits attention is a curvilinear, inverted U-shaped function. This relationship is based upon the observation that people prefer stimuli of medium intensity, a concept first proposed by Wilhelm Wundt (see Chapter 2). (*Bottom*) Actual data for three age groups showing the relationship between attentional preferences and auditory stimulus sequences (rate of presentation of an auditory stimulus). The faster the rate, the more attention given to the auditory stimulus—but only up to a point for the 14- and 20-year-olds. These data are clearly consistent with the idealized inverted U-shaped function. Data for the 8-year-olds, however, show a continual increase in attention with increasing presentation rate. Perhaps the level of auditory presentation for eliciting maximal attention has not been reached for the younger subjects in this experiment (Boesch, Baltes, & Schmidt, 1968).

haps easiest to see the survival value of infant preferences for novel stimuli. If the infant continued to prefer to look at familiar stimuli, there would be little motivation for exploring the vast array of visual information in the environment. The rapid development of an overriding interest in novelty allows the infant to learn and to develop cognitively.

Memory Do infants remember what they have perceived? The answer is, unequivocally, yes. Many studies of infant learning show that very young infants can learn and, therefore, must be able to retain information for some period of time. Other, more direct studies of infant memory show that as early as six weeks of age children can recognize visual stimuli they have seen before. In fact, by two months of age infants can retain visual information for as long as twenty-four hours. This is especially impressive because, in one study reporting this long-term retention, infants were allowed to look at the visual stimulus to be remembered for only four and a half minutes (Martin, 1975). Other studies have shown that visual information can be retained as long as two weeks by infants five months of age (Fagan, 1973).

Most research on infant memory has dealt with memory of visual stimuli. But there is recent evidence that tactile recognition memory develops by at least one year of age (Gottfried & Rose, 1980). And auditory memory appears to develop remarkably early; by four weeks of age infants can recognize a word their mothers repeat to them following a delay of forty-two hours between the last presentation and the recognition test (Ungerer, Brody, & Zelazo, 1978).

Conceptualizing Can infants form concepts? Do they have ideas about things? To the extent that a concept is a *generalized* way of acting toward or thinking about something, the answer appears to be yes. Some of these concepts occur very early in life and are likely to have adaptive value. For example, one of the most striking findings about infant speech perception indicates that infants have concepts of individual speech sounds that are similar to those of adults (Eimas, 1975). In order to appreciate the significance of this finding, it is important to know something about how adults perceive speech sounds. The acoustical energy changes that underlie the difference between sounds like *ba* and *pa* are continuous. However, we do not perceive *ba* and *pa* in a continuous fashion; there is a point on the energy continuum at which we definitely hear *pa,* not *ba*—there is no "transition zone" in our perception of these two sounds. Psychologist John Flavell illustrates this phenomenon nicely:

> . . . let us suppose that our "ba"-"pa" acoustic dimension was arbitrarily marked off into equal physical segments, like this: 1-2-3-4-5-6. Let us further suppose that adults hear stimuli 1, 2, and 3 as "ba" and stimuli 4, 5, and 6 as "pa," since the dimension's small transition zone lies between stimuli 3 and 4. While sounds 1 and 3 are no more different from each other from the physicist's standpoint than 3 and 5 are from each other, a listener hears the members of the first pair as the same sound ("ba") and the members of the second pair as two different sounds ("ba" and "pa"). This is a clear instance of categorical speech perception (Flavell, 1977, p. 166).

We might expect that the development of speech sound categories is entirely a result of being exposed to a particular language; that is, that we can learn adult speech sound categories of a particular speech sound categories of a particular language by listening to adults speak that language. Indeed, there is evidence to support the idea that such categories are modified through learning (Walk, 1981). However, the work of Eimas and others suggests that infants as young as one month of age already have certain adult-like speech sound categories; for example, both infants and adults appear to hear *pa* instead of *ba* at approximately the same point on the acoustical dimension. This suggests that at least certain aspects of the perception of speech sounds are unlearned, though probably not species-specific because certain other animals also appear to perceive speech sounds in a categorical manner (Trehub, 1979; Aslin, Pisoni, & Jusczyk, 1983).

The work on infant speech perception suggests that some of the infant's concepts may not depend upon learning for their emergence. But other concepts do. The famous Swiss developmental psychologist Jean Piaget theorized that children spend the first two years of life acquiring the idea that objects and people are rather *permanent* fixtures in the environment. Piaget labeled this idea the **object concept,** and argued that its acquisition is crucial for the continuation of cognitive development beyond infancy. Piaget's theory states that infants go through a series of stages in acquiring the object concept. For the first four months of life they have an unrealistic notion about objects; basically, it is that objects cease to exist when they are out of the child's sight. Unless the child is looking at, touching, or otherwise perceiving an object, it is, in effect, nonexistent. This does not mean that infants under four months of age have no memory. In fact, infants do show signs of *recognizing* a toy they have seen or played with at an earlier time. However, Piaget would argue that the memory for the object does not include the notion that the object has continued to exist in the interim.

Through a process of continual interaction with people and objects in the environment, coupled with increasingly coordinated and refined intellectual and motor abilities, infants older than four months begin to perceive objects in a more objective fashion. That is, children begin to realize that the existence of objects in the environment does not depend upon someone perceiving those objects; the objects have a reality that is independent of the perceiver. The factual basis for Piaget's arguments is his observation that, until the age of about two years, children do not engage in a systematic, thorough, and accurate search for missing objects, and they do not fully appreciate the variety of things that can happen to objects when they are hidden from view. We will treat Piaget's theory of cognitive development in more detail elsewhere, especially in Chapter 14. For now, it is sufficient to note that Piaget has had more to say about conceptual development in general than anyone else, and that he viewed infancy as a germinal period for the emergence of concepts that are necessary for all forms of advanced thinking.

Development of Communication and Language

Communication refers to the process of exchanging information among people, other animals, or machines. *Language* is a specialized form of communication involving symbols and what they stand for, and rules for combining the symbols. Although they may not intend to, children begin communicating with their mothers even before birth. The first fetal movements detected by a mother convey information to her about the well-being of her child, and may elicit feelings of surprise, exhilaration, or, in some instances, distress. Crying is the first sound a newborn makes, and the newborn's cry at birth usually communicates that the child is functioning normally. This may be one of the few occasions on which this particular form of communication elicits feelings of relief and happiness from the parents.

There are, of course, many other kinds of messages and modes of communication during infancy. It appears that crying becomes differentiated as early as the first few weeks of life, and the different forms it takes can communicate very different messages. Infants less than a month old show slightly different acoustical patterns for cries associated with hunger, anger, and pain. And what is most interesting is that their mothers can differentiate and respond appropriately to these different patterns (Wolff, 1969). This is obviously a very adaptive set of communicative skills for both infant and mother to possess.

Looking at and visually scanning a human face is another communicative skill that is evident early, soon after birth in many infants. Parents tend to reciprocate their infants' attempts to gaze at them, but reduce responsiveness when the infant turns away. Visual fixation of the parent can communicate that the infant is alert, healthy, and interested in interacting. Turning away may communicate that the infant has had enough stimulation (Stern, 1974).

Babbling and smiling represent two major forms of communication that occur later than the other behaviors we have mentioned. Smiling does occur in some newborns, but what is termed *social smiling*—smiling in response to others—does not usually emerge until about six weeks of age at the earliest. Infants begin to vocalize individual sounds between one and two months of age, but true **babbling,** wherein sequences of sounds such as "bababa-ba" are emitted, does not occur until about four months of age. It is interesting that even babies born without hearing babble, and those without sight smile, both at about the same time as normal infants (Freedman, 1974). Like visual gaze, smiling and babbling can communicate information about the health and state of the infant, and they may be important in stimulating and maintaining a high level of parental affection for and involvement with the infant (Bowlby, 1958).

There is controversy over the role of early babbling in later language development. We don't know for sure whether the infant's early sounds form some sort of continuum with the first recognizable words, or whether babbling and speech are the outcomes of two different developmental processes. Regardless, we do know something about the developmental course of language acquisition, beginning with infants' responses to spoken language. We have already mentioned that infants are tuned in to certain elements of speech by the first month of life. Presumably they begin putting together these basic speech sound concepts with other aspects of language they are exposed to in order to form a means of understanding speeh. Some linguists and psychologists argue that language comprehension develops so rapidly that the infant must have some sort of innate basis for identifying the rules that allow the meaning of speech to be understood.

We will not detail the many linguistic accomplishments of the infant here, except to note that by one year of age children can respond appropriately to many different verbal commands, use single words to name things, and express various intentions. By two years of age children have a vocabulary of over two hundred words, and use multiword utterances (sentences) to convey meaning. Throughout infancy children comprehend much more language than they can express.

Emotional Development

The earliest scientific investigations of emotional development in infancy reported that newborns do not experience differentiated emotional states, only a state of generalized excitement. According to these investigators, it was not until about three months of age that emotional differentiation began (Bridges, 1932).

In light of more recent evidence, the notion that the period from birth until three months is characterized by a single, undifferentiated emotional state is shown to be oversimplified. Researchers using longitudinal methods have been able to identify basic personality profiles that include emotional reactivity in infants as young as two months of age (Thomas & Chess, 1977). The personality of the newborn and young infant is often called *temperament*, and is thought to reflect mainly biological (genetic and hormonal) and prenatal environmental influences. The work of Alexander Thomas and his colleagues indicates that several aspects of temperament can be identified in infants before the age of three months. These include activity level, rhythmic pattern, distractibility, tendency to approach or withdraw from stimuli, adaptability, attention span and persistence, intensity of reaction, responsiveness, and mood quality. Of particular interest is the fact that these researchers have observed a good deal of stability in temperament in their sample over the first ten years of life. Also, three major kinds of temperament profiles observed in this sample of children have been identified: the easy child, the difficult child, and the slow-to-warm-up child. Details of these three types are shown in Table 6.4.

Thus the work of Thomas and his associates, and that of other researchers (for example, Bridger & Birns, 1968), suggests that the infant less than three months of age may experience more than generalized excitement as an emotional state. It also shows that there are stable *individual differences* in emotional response, and in temperament generally, which can be identified very early in life, and may reflect genetic differences among infants. These findings, especially the ones concerning individual differences in temperament, raise some very important practical issues. First, if some aspects of temperament are stable over time, we may be able to identify children who are likely to develop emotional disorders early enough so that effective preventive measures can be applied. Second, we may have to reevaluate our current notions of parenting and educating children. So-called cookbook methods of discipline and training, those that specify one "best" technique, will have to be revised. Training methods that are best for the "easy" child may fail miserably when applied to the "slow-to-warm-up" child (LaBarba, 1981).

The infant emotion that has been studied the most by psychologists is *fear*. Two classes of stimuli have been associated with fear, or at least wariness, in infants: *strange people* and *separation* from the caregiver. Fear associated with dren begin communicating with their mothers even before birth. The first fetal movements detected by a mother convey information to her about the well-being of her child, and may elicit feelings of surprise, exhilaration, or, in some instances, distress. Crying is the first sound a newborn makes, and the newborn's cry at birth usually communicates that the child is functioning normally. This may be one of the few occasions on which this particular form of communication elicits feelings of relief and happiness from the parents.

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TABLE 6.4 Child Temperament Types

Type of Child	Activity Level	Rhythmicity	Distractibility	Approach Withdrawal	Adaptability	Attention Span and Persistence	Intensity of Reaction	Threshold of Responsiveness	Quality of Mood
	The proportion of active periods to inactive ones	Regularity of hunger, excretion, sleep, and wakefulness	The degree to which extraneous stimuli alter behavior	The response to a new object or person	The ease with which a child adapts to changes in the environment	The amount of time devoted to an activity, and the effect of distraction on the activity	The energy of response, regardless of its quality or direction	The intensity of stimulation required to evoke a discernible response	The amount of friendly, pleasant, joyful behavior as contrasted with unpleasant, unfriendly behavior
Easy	*Varies*	*Very Regular*	*Varies*	*Positive Approach*	*Very Adaptable*	*High or Low*	*Low or Mild*	*High or Low*	*Positive*
Slow to Warm Up	*Low to Moderate*	*Varies*	*Varies*	*Initial Withdrawal*	*Slowly Adaptable*	*High or Low*	*Mild*	*High or Low*	*Slightly Negative*
Difficult	*Varies*	*Irregular*	*Varies*	*Withdrawal*	*Slowly Adaptable*	*High or Low*	*Intense*	*High or Low*	*Negative*

SOURCE: Thomas, Chess, & Birch, 1970.

unfamiliar adults is often first observed at about six months of age and declines by about fifteen months (Mussen, Conger, & Kagan, 1980). It used to be thought that "stranger anxiety" is universal in children of this age range, but we now know that this is not the case. Many children do not show a fear of strangers, and it may appear only under certain conditions in those who do (Rheingold & Eckerman, 1973). Perhaps the variability that is observed in stranger anxiety can be accounted for in part by the differences in temperament we have discussed.

Fear of separation from the caregiver is a well-documented phenomenon, but it also shows much variability in infants. Children begin to react with distress to the disappearance of the primary caregiver at about eight to twelve months; this reaction begins to disappear between the ages of twenty-four and thirty months. The intensity of the reaction seems to vary depending on the temperament of the child, the quality of the affectional bond between child and caregiver, and the degree of surprise and unpredictability associated with the separation. Nevertheless, the fear of separation appears to develop at about the same time in children growing up in a variety of settings, where contact with caregivers "varies from continuous, as in the !Kung San infants of the Kalahari Desert, to regular and prolonged separation, as when infants attend a day-care center every day," as in an Israeli kibbutz (Mussen, Conger, & Kagan, 1980, p. 175). This lack of cross-cultural variance, despite differences in the amount of parent-child contact among different cultures, suggests a genetic basis for fear of separation. It is not difficult to imagine that a fearful response to separation would be highly adaptive. Crying upon separation from a parent could signal the parent or other adult as to the location of a young infant who, if left alone for very long, might starve, die from exposure, or encounter danger and be unable to escape. Of course, parents must be able and willing to respond to this distress signal appropriately. Some developmental theorists—most notably John Bowlby (1958)—have argued that human and other primate mothers may be innately "programmed" to retrieve their separated infants when they hear them crying.

The development of an emotional bond, an **attachment,** between the child and one or more caregivers is one of the most prominent features of infancy. The formation of attachments occurs in three major stages or steps:

> First, the infant is attracted to all social objects and comes to prefer humans to inanimate objects. Second, the infant gradually learns to discriminate familiar and unfamiliar people. Finally, the infant develops the capacity to form a special relationship with certain specific individuals with whom he or she actively seeks to maintain contact (Hetherington & Parke, 1979, p. 222).

Specific attachment emerges by about seven months of life in humans, and is a universal phenomenon in humans and in many other species of animals.

The development of attachments is complex and is influenced by a variety of important factors. Moreover, attachment between infant and caregiver appears to be important for later social functioning. We will explore attachment, or *bonding,* in greater detail in Chapter 17.

Learning and Behavior

Chapter 7 Habituation and Classical Conditioning

Chapter 8 Instrumental Learning

UNIT III

> Change, and the ability to change, are at the heart of all the varied meanings and definitions that have been applied to the term "learning." An organism that can change its characteristics and alter its activities has a huge advantage over forms of matter that cannot, the latter being tightly bound to the physical environment surrounding them (Howe, 1980, p. 2).

Learning capacities permit the behavioral flexibility that is essential for species faced with changing sources of food and water, unpredictability of predators and competitors, and other environmental variations that demand prompt adjustments for survival. Learning, as a subject of psychological inquiry, has probably received more theoretical and research attention than any other topic covered in this text.

In order to have a convenient starting point, we have defined *learning* very broadly, as the *acquisition and retention of information* resulting from *experience*. Scientifically, we cannot say that learning has occurred unless a change in behavior has been observed, a change that results from certain kinds of experience. In fact, some psychology texts define learning only in terms of behavioral change, and do not mention acquisition and retention of information. We believe that such definitions are unduly narrow because they do not emphasize the processes that bridge the gap between experience and behavioral change.

What kind of information is acquired and retained as a result of experience? Traditionally, psychologists have proposed that *associations* between aspects of the environment and behavior—stimuli and responses—make up the content of learning. The traditional view emphasizes the direct effects of the environment on behavior and the relatively automatic and involuntary nature of learning. This view dominated psychology during the first half of the twentieth century. However, an alternative, and more enriched, view of learning has been proposed more recently. This alternative view states that learners acquire *information* about the *predictable relationships* that exist among stimuli or between responses and stimuli. In other words, learners come to know something about the predictability of environmental events and the relationship of their actions to those events. Learners actively form thoughts or *cognitions* about the environment, and about their behavior in relation to the environment. They change their behavior because of these expectations. This is often referred to as a *cognitive* view of learning.

The contrast between traditional and cognitive views of learning emerged as a major issue during the early 1970s. Although this issue has yet to be resolved definitively, a major trend toward cognitive explanations of learning, even animal learning, was discernible by the mid-1970s.

> It should be apparent that there has been a recent acceleration of activity in cognitive psychology and in the application of cognitive principles to the problems of animal learning. In part, this emphasis reflects the vitality of cognitive concepts in other areas of psychology, especially in developmental and human learning. But its reception in animal learning is undoubtedly conditioned upon a prior dissatisfaction with the heritage of the mechanistic philosophy, which has continued to govern much of our thinking even though it has not been officially sanctioned by learning theorists for a number of years. . . . It will undoubtedly take a number of years to work out its implications, and even if cognitive psychology never becomes more than a toy, it will take some time for us to tire of playing with it. It seems safe to conclude that the current trend of growing interest in cognitive psychology is going to continue at least through the 1970s (Bolles, 1975, pp. 216–17).

As it turned out, Bolles was right. The cognitive focus has grown, and is very much alive in the psychology of learning, as well as in other areas of psychology.

7

Habituation and Classical Conditioning

Habituation: The Simplest Form of Learning

Classical Conditioning

The Development of Classical Conditioning

Alternative Explanations of Classical Conditioning

Classical Conditioning and Survival

Chapter Preview

Habituation—responding less and less to a repeated stimulus—has been characterized as the simplest form of learning. It has been demonstrated in a wide variety of species, from single-celled organisms to humans. The ability to habituate is present soon after birth in humans and many other animals, and it would seem to have a good deal of survival value.

Classical conditioning, studied extensively by Ivan Pavlov, involves the conditioning of a reflex to a stimulus that does not ordinarily elicit that reflex. Pavlov showed that the salivary reflex in dogs, which can be elicited naturally by placing meat powder on the dog's tongue, could become conditioned to the clicking sound made by a metronome. He accomplished this by presenting the beating of the metronome to the dog, following it closely with the meat powder, and repeating this procedure a number of times. After several repetitions the dog would salivate to the sound of the metronome alone.

Classical conditioning has been demonstrated in many different species. Like habituation, classical conditioning can be observed early in the lives of those species studied developmentally, and the basic ability to condition appears to undergo few significant changes with increasing age.

Although classical conditioning is considered an associative learning process, interpretations differ as to the nature of what is learned. For the most part, traditional learning theories have emphasized the relatively automatic reflex nature of classical conditioning. Since the early 1970s, however, more attention has been given to the cognitive aspects of classical conditioning, with emphasis on the cognitions the learner acquires during conditioning.

Classical conditioning may play an important role in the attachment of emotional responses to particular environmental stimuli. For example, the formation of affectional bonds between children and their parents may be brought about in part by classical conditioning. This kind of conditioning also appears to be important in acquiring aversions to particular stimuli, aversions that generally promote survival. This is shown most clearly in the work of John Garcia and others extending some of the basic principles of classical conditioning.

Habituation: The Simplest Form of Learning

Habituation refers to a process in which repeated presentations of a stimulus bring about a gradual decline in the response. We may startle (the response) at a sudden loud noise (the stimulus), such as an automobile backfire or the starting of a jackhammer ripping up a sidewalk. However, if the backfiring continues, or the jackhammer stops and starts frequently, the startle and fear will decline and may cease altogether. In a loose sense, habituation is getting used to something in the environment. But in what way is habituation learning? If learning involves acquiring and retaining information, then clearly habituation indicates that the organism has learned something about the stimulus—for example, that the stimulus might not be worth continuing to pay attention to. Note that habituation does not refer to sensory fatigue or sensory adaptation, phenomena which could also produce a decline in response as a result of repeated presentations of a stimulus. In other words, in order for the decline in startle to a repeated loud noise to qualify as habituation, there must be evidence that the sensory receptors of the ear had not become worn out by, or adapted to, the repeated auditory stimulus. This could be shown by introducing a *new* sound following a decline in response to the original sound. Let us say the new auditory stimulus is a sound of different pitch, but of an intensity equal to or less than that of the original stimulus. If presentation of this new stimulus resulted in *recovery* of the startle response, then we would have evidence that the original decline in the startle response was not due merely to sensory fatigue or sensory adaptation to a particular level of auditory intensity (Figure 7.1).

Habituation has been investigated in many species. Studies of *Aplysia,* a marine slug, have even pinpointed specific neurochemical changes that accompany habituation (Farley & Alkon, 1985). However, nervous systems may not be necessary for all forms of habituation, for it has also been documented in a species of plant genus *Mimosa,* whose leaflets close and droop in response to tapping, cutting, heating, darkness, or electrical current. Repeated stimulation reduces leaflet sensitivity, an apparent instance of habituation (Dewsbury, 1978).

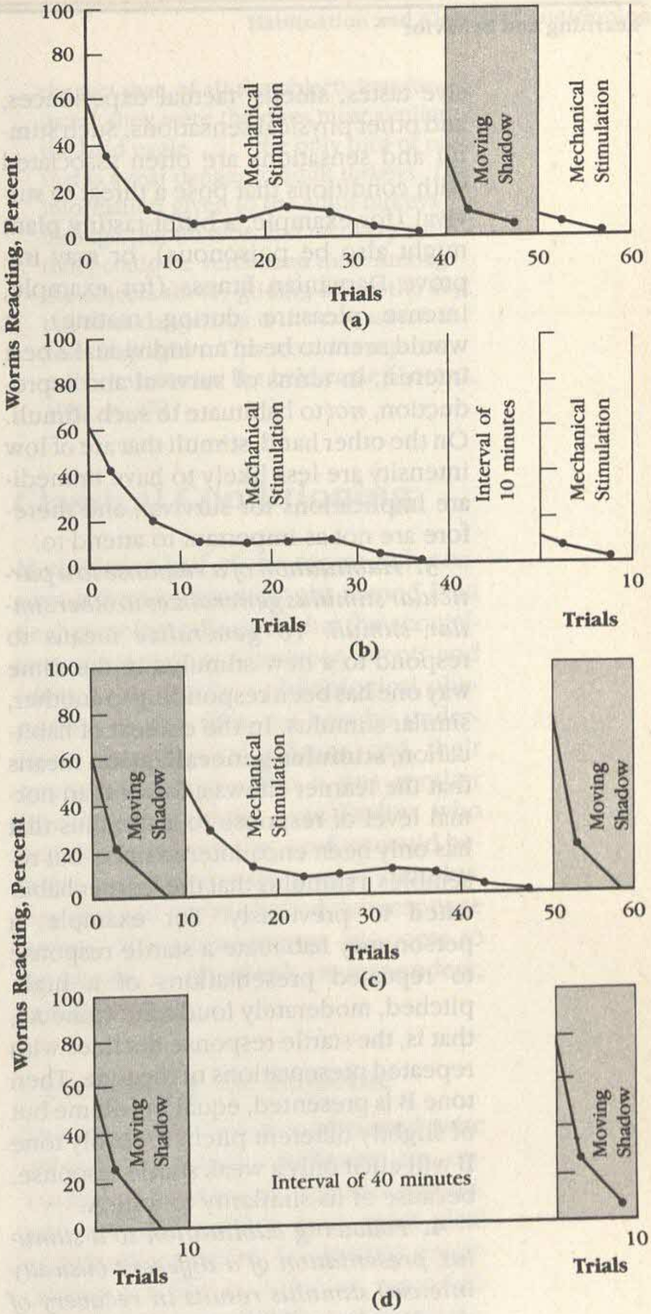


Figure 7.1 Habituation and recovery responses in *Nereis pelagica* (a marine worm) to mechanical shock and a moving shadow. The habituated response involves withdrawal of the worm into its tube as a result of repeated presentations of the shock or moving shadow. In (a) repeated mechanical stimulation results in habituation within 10 trials. The response shows recovery to a new stimulus—the moving shadow—but quickly declines. The response does not recover to the reintroduction of mechanical stimulation on trial 50. In (b) a different group of worms that were not exposed to the moving shadow shows the same pattern of responding as those in (a). In (c) and (d) the situation is reversed, with exposure to the moving shadow preceding the mechanical stimulation (c), or an "empty" interval (d). The fact that mechanical stimulation has no effect on subsequent responsiveness to the shadow, and vice versa, appears to qualify this pattern of responding as habituation rather than sensory fatigue.

Characteristics of Habituation

Several features characterize the phenomenon of habituation (Thompson & Spencer, 1966), a few of which are summarized here:

1. *Withholding of the stimulus following habituation allows the response to recover over time.* Following habituation the subject shows a lower than normal response to the stimulus for some time, but not permanently. Such retention has been shown for several species. For example, in *Aplysia,* a marine slug called the sea hare, habituation lasts up to three weeks, in earthworms up to four days, in rats up to forty-two days, and in humans up to a week (Leaton & Tighe, 1976).

2. *The weaker the stimulus, the more rapidly the response habituates; repeated presentations of intense stimuli may not result in habituation.* This statement makes perfect adaptive sense. Intense stimuli might include such things as bright lights, loud noises, extreme heat or cold, highly pleasurable or aversive tastes, smells, tactual experiences, and other physical sensations. Such stimuli and sensations are often associated with conditions that pose a threat to survival (for example, a bitter-tasting plant might also be poisonous), or may improve Darwinian fitness (for example, intense pleasure during mating). It would seem to be in an individual's best interest, in terms of survival and reproduction, *not* to habituate to such stimuli. On the other hand, stimuli that are of low intensity are less likely to have immediate implications for survival, and therefore are not as important to attend to.

3. *Habituation of a response to a particular stimulus generalizes to other similar stimuli.* To *generalize* means to respond to a new stimulus in the same way one has been responding to another, similar stimulus. In the context of habituation, **stimulus generalization** means that the learner shows a lower than normal level of response to a stimulus that has only been encountered once, but resembles a stimulus that the learner habituated to previously. For example, a person may habituate a startle response to repeated presentations of a high-pitched, moderately loud tone (tone A); that is, the startle response declines with repeated presentations of the tone. Then tone B is presented, equal in volume but of slightly different pitch. Probably tone B will elicit only a weak startle response, because of its similarity to tone A.

4. *Following habituation to a stimulus, presentation of a different (usually intense) stimulus results in recovery of the dishabituated response.* The meaning of **dishabituation** becomes clear if we return to the example of habituating to a high-pitched, moderately loud tone. Suppose the startle response has become habituated as a result of several presentations of the tone. But suddenly a flash of light and a deafening crack of thunder interrupt the silence of the laboratory. The experimenter then presents the original tone, to which the subject had habituated before. Now there is full recovery of the startle response. Recovery of the habituated startle response following the thunder and lightning would be an example of dishabituation.

Habituations's Adaptive Significance

The ability of humans to habituate may emerge as early as the first few days of life (Field, Dempsey, Hatch, Ting, & Clifton, 1979; Friedman, Bruno, & Vietze, 1974). Thus infants may come into the world already equipped with the ability to begin learning, and to direct their attentional responses to various stimuli in a biologically meaningful way.

The ability to adjust the level of response to repeated encounters with various stimuli can be quite adaptive. An organism might never be motivated to explore new situations if it were unable to habituate its curiosity about, and perhaps fear of, *old* situations. Imagine what the implications for survival would be for animals whose environments have been invaded by man if they were unable to habituate to the cacophonous sounds, sights, vibrations, and odors associated with cars, trains, airplanes, smelters, and crowds of moving humans. That such habituation occurs is indicated in the following:

> Adult starlings surely have an innate tendency to flee from onrushing objects, yet they can become so habituated to automobiles that they will feed on the edge of a highway, unruffled by the passage of cars a few feet away. They even sometimes will drop down between speeding vehicles to reach a

> scrap of food lying on a freeway lane marker. . . . In some way the fact that passing cars fail to pursue fleeing starlings is recorded by the bird's brain and it learns that cars can be safely ignored. You can be sure that starlings do not habituate to onrushing peregrine falcons [a natural predator] (Alcock, 1979, p. 64).

When an organism habituates, it learns which aspects of a situation are harmless or not worth attending to. However, certain elements of habituation can also provide information about things in the natural environment that *are* dangerous. Wild turkeys act fearful and try to escape when they see any object above them moving in dark silhouette against a lighter background. In the normal environment the object might be a hawk or an eagle moving across the sky. But laboratory experiments have shown that any dark object moving overhead against a light background can be an effective stimulus. Each *different* object that is presented to a turkey will elicit an escape response, but if the same object is presented repeatedly the turkey will habituate to it rapidly. Objects that are the strongest "releasers," or elicitors, of escape typically are those the turkeys have not encountered for the longest period of time. The famous ethologist Konrad Lorenz describes how *recovery* of the habituated response turns out to have adaptive value for turkeys in their normal environments:

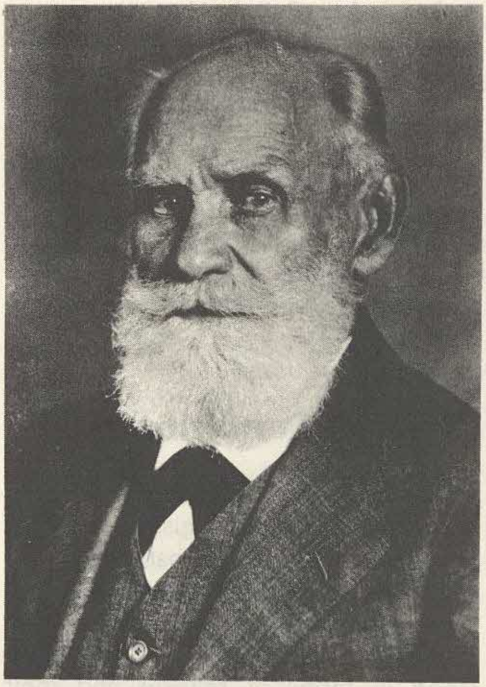
> The free-ranging turkeys at our institute in Seewiesen gave the strongest escape responses to a dirigible which, rented by an advertising firm, flew its round over the vicinity about twice each year.
> Among all of the objects tested, buzzards exerted the weakest releasing influence because they were seen daily flying above our area. This was so in spite of the fact that, of all the objects investigated, they were the ones most similar to the bald eagle . . . the only bird of prey that is a real danger to adult turkeys. The information given to the adult turkeys through [habituation and recovery with time] could be verbalized thus: Among the objects slowly gliding across the sky, thé most dangerous is the one *which is seen least often.* This would unequivocally characterize the bald eagle (Lorenz, 1981, p. 272).

Classical Conditioning

In the latter half of the nineteenth century, a Russian physiologist named Ivan Sechenov hypothesized that the acquisition of associations between events and ideas is ultimately a physiological phenomenon, and thus can best be understood in terms of reflexes and their neurological bases. But it was another Russian physiologist, Ivan Pavlov, who first demonstrated that a reflex could become associated with a new stimulus, one that had never elicited that response before. This phenomenon has come to be known as **classical,** or respondent, **conditioning.**

Conditioning the Response

The responses Pavlov conditioned were reflexive in nature. **Reflexes** are unlearned responses to specific stimuli, and are not subject to a great deal of voluntary control. In classical conditioning a reflex is called an **unconditioned response (UCR),** and the stimulus that ordinarily elicits a reflex is called an **unconditioned stimulus (UCS).** Remember, this particular kind of stimulus-response relationship (UCS-UCR) is genetically programmed, and it does not depend on learning for its occurrence.



Ivan Pavlov, a Russian physiologist, undertook pioneering research on a form of learning called classical conditioning.

Pavlov demonstrated that a dog could *learn* to respond reflexively to a stimulus other than a UCS. Specifically, he showed that the salivary reflex, which can be elicited naturally by placing meat powder on a dog's tongue, could become conditioned to the clicking of a metronome. The basic recipe for such learning is as follows: First, present the clicking metronome, or some other **neutral stimulus (NS)** to the dog. Follow this immediately with a dash of meat powder (UCS) on the dog's tongue, which results in the salivary response (UCR). Repeat these procedures several times in succession, and then present only the clicking metronome. If classical conditioning has occurred, the dog will salivate to the clicking metronome *without the meat powder.* Once this happens, the metronome is no longer called an NS, because it is no longer neutral; rather, it is referred to as a **conditioned** (or conditional) **stimulus (CS).** The salivation in response to the metronome is called a **conditioned response (CR).** These procedures are outlined in Figure 7.2.

Two major kinds of relationships are acquired in classical conditioning. First is the relation between the CS and the UCS. For example, the dog learns that the metronome predicts or signals the occurrence of the meat powder. Second, there is the relation between the CS and the CR; the dog learns to salivate in response to the clicking metronome, as if anticipating the meat powder. The acquisition and retention of these relationships generally depend heavily on *temporal contiguity* and *repetition.* In classical conditioning, **temporal contiguity** refers to the fact that the NS and UCS occur close together in time. Pavlov considered temporal contiguity and the order of presentation of the NS and UCS to be all-important:

> . . . *the first and foremost requisite for the formation of a conditioned reflex lies in the coincidence in time of the action of a previously indifferent agent with the action of an unconditioned agent which evokes a definite unconditioned reflex.*
>
> The second important requisite is that the *conditioned reflex can be formed only if the indifferent agent somewhat precedes the action of the unconditioned stimulus.* If the order is reversed, i.e., if we apply the unconditioned stimulus first, and the indifferent agent afterwards, there will be no conditioned reflex (Pavlov, 1957, pp. 198–99; italics are his).

Although Pavlov considered temporal contiguity of the stimuli essential for conditioning, there are some interesting and significant exceptions to this rule, which are discussed later in the chapter. Moreover, although repetition usually is

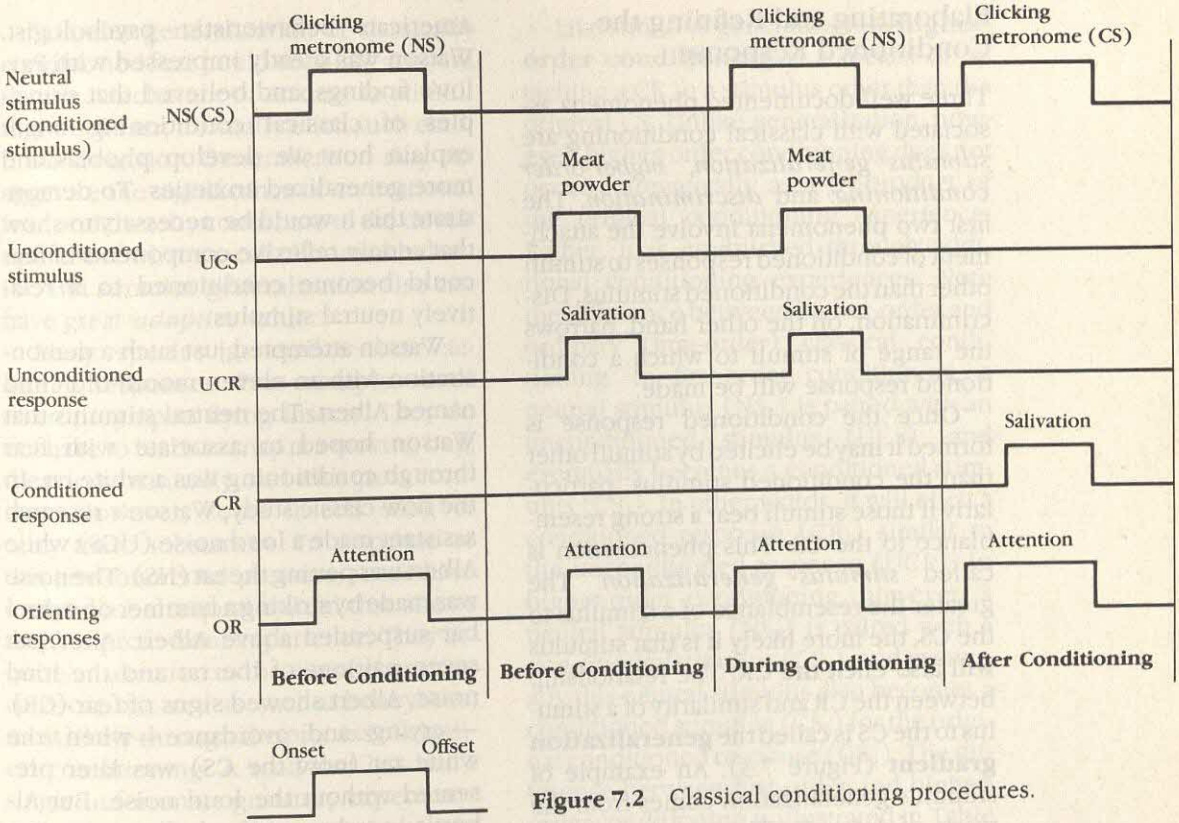


Figure 7.2 Classical conditioning procedures.

considered part and parcel of the classical conditioning paradigm, it may not be necessary for the formation of *all* CS-CR relations. Also note that the NS is not a neutral stimulus for other responses, even though it did not elicit a UCR prior to conditioning in the above example. For example, the clicking of the metronome elicited various alerting or orienting responses on the part of the dog, such as pricking up of the ears and turning the head in the direction of the sound.

Another aspect of classical conditioning that may need clarification involves the similarity between the CR and the UCR. Although the two responses are quite similar in appearance, they are not identical. The CR may take longer to elicit than the UCR, is often weaker, and is generally not as predictable as the UCR. Finally, the physical and motivational states of the organism are very important considerations in determining the relative ease or difficulty in establishing a conditioned response. For example, "If the animal undergoing the experiment is in a more or less drowsy state, the formation of the conditioned reflex either acquires a protracted character, being considerably impeded, or becomes completely impossible" (Pavlov, 1957, p. 200).

This outline of classical conditioning procedures has relied heavily on examples from Pavlov's pioneering research with dogs. These principles have been replicated by other researchers around the world, and they appear to extend to a variety of species, including humans.

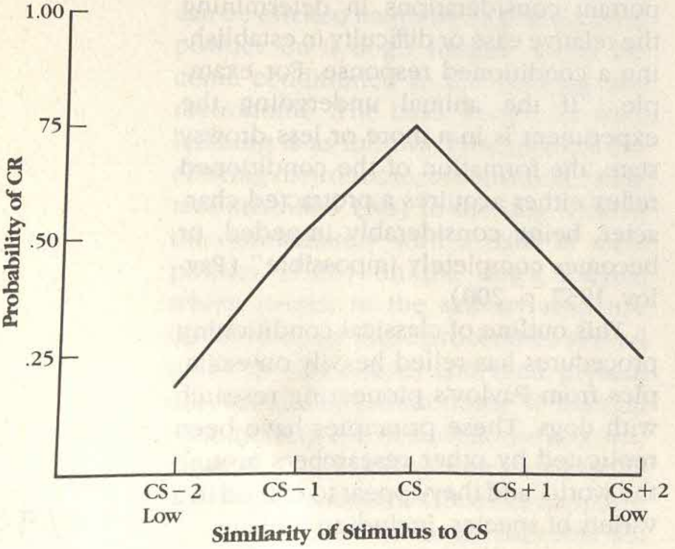
Elaborating and Refining the Conditioned Response

Three well-documented phenomena associated with classical conditioning are *stimulus generalization, higher-order conditioning,* and *discrimination.* The first two phenomena involve the attachment of conditioned responses to stimuli other than the conditioned stimulus. Discrimination, on the other hand, narrows the range of stimuli to which a conditioned response will be made.

Once the conditioned response is formed it may be elicited by stimuli other than the conditioned stimulus, particularly if those stimuli bear a strong resemblance to the CS. This phenomenon is called *stimulus generalization.* The greater the resemblance of a stimulus to the CS, the more likely it is that stimulus will also elicit the CR. The relationship between the CR and similarity of a stimulus to the CS is called the **generalization gradient** (Figure 7.3). An example of stimulus generalization comes from the work of John B. Watson, the famous American behavioristic psychologist. Watson was greatly impressed with Pavlov's findings, and believed that principles of classical conditioning might explain how we develop phobias and more generalized anxieties. To demonstrate this it would be necessary to show that certain reflexive components of fear could become conditioned to a relatively neutral stimulus.

Watson attempted just such a demonstration with an eleven-month-old child named Albert. The neutral stimulus that Watson hoped to associate with fear through conditioning was a white rat. In the now classic study, Watson's research assistant made a loud noise (UCS) while Albert was petting the rat (NS). The noise was made by striking a hammer on a steel bar suspended above Albert. After just seven pairings of the rat and the loud noise, Albert showed signs of fear (CR) — crying and avoidance — when the white rat (now the CS) was later presented without the loud noise. But Albert's newly acquired fear was not restricted to the rat. Five days later it could be elicited by stimuli such as a rabbit, a dog, a sealskin coat, and even a Santa Claus mask! Apparently Albert's fear had generalized to stimuli that were furry in nature (Watson & Rayner, 1920).*

Figure 7.3 A stimulus generalization gradient.



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* The "little Albert" experiment, reported over sixty years ago, would be considered unethical by current standards for conducting psychological research with children. Also, some of Watson's contemporaries were unable to replicate the Watson and Rayner findings (Harris, 1979). Nevertheless, there have been other demonstrations of what appears to be classically conditioned fear in humans (Jones, 1930), and many animal experiments report classical conditioning and generalization of fear to various visual and auditory stimuli (Flaherty, Hamilton, Gandelman, & Spear, 1977). So principles of classical conditioning and stimulus generalization may be responsible at least in part for the development of certain anxieties and phobias in humans.

Stimulus generalization of classically conditioned fear could certainly account for the attachment of anxiety to stimuli that would not normally elicit such emotional behavior. Generalization may exaggerate the significance of an irrational fear, and thereby contribute to the development of what we call abnormal behavior. But stimulus generalization also can have great *adaptive* value.

Many species generalize their acquired responses. For example, toads often prey upon flying insects. They do not have to learn to snap at a moving bug; they do so naturally, and with great accuracy. However, some insects sting or carry toxic substances. In response to this environmental pressure, toads have evolved a behavioral system that allows them to profit from experience. They acquire an aversion to the visual characteristics of toxic insects, such as honeybees, most likely through the process of classical conditioning. A toad that has but a single unfortunate gustatory experience with a honeybee will be quite reluctant to snap at a bee in the future, or indeed at any flying insect that resembles a honeybee (Brower & Brower, 1962). The ability to generalize a conditioned fear response to other species similar in appearance and behavior to honeybees is clearly adaptive. Without generalization, learning would be inefficient, and its contribution to individual fitness would be lowered considerably.

Like stimulus generalization, **higher-order conditioning** is a means of attaching a CR to a stimulus other than the original CS. Unlike generalization, however, higher-order conditioning does not occur automatically as a by-product of the original conditioning experience. Rather, it is established through additional conditioning experiences. Note the difference between higher-order and ordinary (first-order) classical conditioning: In first-order conditioning, a neutral stimulus (NS_1) is paired with an unconditioned stimulus (UCS), and eventually becomes a conditioned stimulus (CS_1). In other words, it will elicit a conditioned response (CR_1) similar to the unconditioned response (UCR). In higher-order conditioning, however, a neutral stimulus (NS_2) is paired with a *conditioned* stimulus (CS_1), and eventually this neutral stimulus also becomes a conditioned stimulus (CS_2) for the original conditioned response (CR_1). The difference between first-order and higher-order conditioning is illustrated in Table 7.1 using a hypothetical example. In this example, a child becomes conditioned to fear not only a white rat but also the sound of the word *rat*. Theoretically, higher-order conditioning could proceed beyond the second order, for example, by pairing the word *nasty* with the word *rat*. Although conditioning beyond the second order is difficult to establish in laboratory settings, many psycholo-

TABLE 7.1 First-Order and Higher-Order Conditioning Procedures

	Stimulus Response Relationships	Hypothetical Extension of the "Little Albert" Study
First-Order Conditioning	1. NS_1 paired with UCS 2. Repetition of NS_1–UCS 3. CS_1 elicits CR_1	1. White rat (NS_1)–loud noise (UCS) 2. Repetition of white rat (NS_1)–Loud noise (UCS) 3. White rat (CS_1) $\rightarrow$ fear (CR_1)
Second-Order Conditioning	4. NS_2 paired with CS_1 5. Repetition of NS_2–CS_1 6. CS_2 elicits CR_1	4. The word *Rat* (NS_2)–white rat (CS_1) 5. Repetition of *Rat* (NS_2)–white rat (CS_1) 6. *Rat* (CS_2)–fear (CR_1)

gists believe that it may occur more readily outside the laboratory, where it is likely that the original CS-UCS events will be reencountered occasionally, thereby strengthening the higher-order relationships.

Pavlov, and many psychologists since Pavlov, emphasized the importance of higher-order conditioning in human language, thought, and emotional behavior. For example, Pavlov theorized that human speech provides an almost limitless source of stimuli that can acquire significant signaling properties through higher-order conditioning. It may well be that a great deal of the meaning and emotional connotation we attach to various words and phrases develops through higher-order conditioning. It is even conceivable that the development of racial prejudice, for instance, may begin with parents or others who, in the presence of children, associate white, black, or yellow skin colors (NS) with words implying negative evaluations (CS).

Although higher-order conditioning and stimulus generalization provide mechanisms for elaborating a conditioned response, **discrimination** increases the specificity of the CR. In classical conditioning, discrimination occurs whenever a given CR is elicited by one stimulus but not by another. Suppose a dog has been trained to withdraw its right foreleg (the CR) in response to a tone of a particular frequency, say 1,000 Hertz (the CS). During conditioning the tone was paired with an electric shock to the dog's leg (UCS), causing a reflexive leg withdrawal (UCR). If we now present a tone of 800 Hertz, the dog may well withdraw its leg because of stimulus generalization. However, if we never shock the dog when this new tone is repeatedly presented, but do so consistently when the 1,000 Hertz tone, the original CS, is presented, the dog will probably learn to discriminate between the two tones. That is, it will eventually become more likely to withdraw its leg only when the tone that had been paired with shock is presented.

In discrimination learning, an individual learns to respond selectively to stimuli that are reinforced with the UCS, and to inhibit such responding to stimuli not followed by the UCS. In a sense, discrimination is the flip side of stimulus generalization, and provides an adaptive balance in learning. A toad that did nothing but generalize its conditioned fear of the stinging bee to all other flying insects would probably die of starvation in short order. On the other hand, a toad that learned to discriminate between stinging and nonstinging insects on the basis of differences in distinctive visual features might well enjoy a greater degree of individual fitness.

Inhibiting the Conditioned Response

Let us return for a moment to the example of little Albert's conditioned fear of the white rat. Based on the procedures Watson and Rayner used to instill this fear, what would you do to relieve Albert's problem? When presented with this question, many students say they would try to give Albert something rewarding whenever the white rat is presented, and never subject him to the loud noise again. This commonsense solution is not only intuitively appealing, it is scientifically sound — it works. There are really two sets of procedures being proposed here, the two major ways of reducing the strength of the CR — *extinction* and *counterconditioning*.

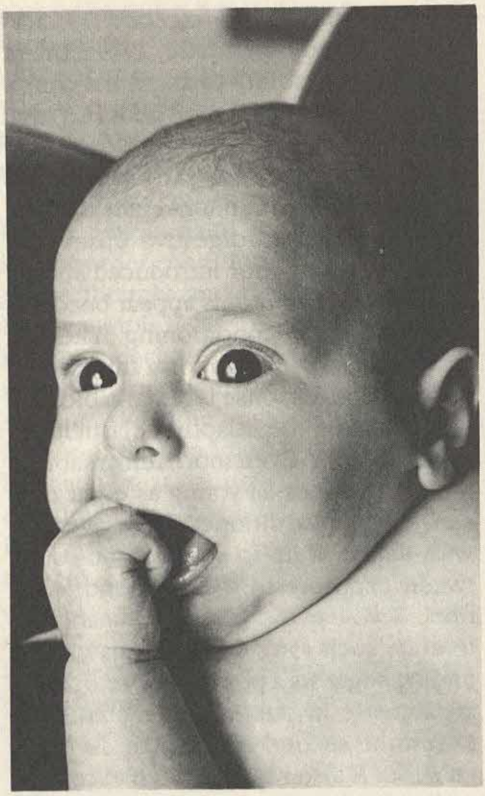
Extinction refers to the gradual decline in a CR (Albert's learned fear) as a result of presenting the CS alone (the white rat without the loud noise) over and over again. Extinction is not exactly unlearning, but rather may involve an *inhibition* of the CR. We suspect this because the CR will regain some of its original strength following a time-out from the extinction trials—repetitions of the CS. This recurrence in strength is called **spontaneous recovery.** Generally, spontaneous recovery becomes less marked as the individual undergoes more blocks of extinction trials.

Counterconditioning goes one step beyond extinction procedures. In addition to withholding the UCS, an attempt is made to condition a new response that is incompatible with the unwanted CR. For example, if we could have the white rat present in the room with Albert, and at the same time get him to laugh (perhaps at the experimenter making funny faces) or to eat some of his favorite foods, we might be able to reduce his fear of the rat. Procedures such as these have been used successfully in reducing similar fears in young children (Jones, 1924). They have also been used in treating adult phobias, again with a great deal of success.

The Development of Classical Conditioning

Until recently few investigations dealt specifically with developmental changes in the ability to learn. This trend appears to be reversing, and the study of the development of learning abilities has begun to grow (Spear & Campbell, 1979). At present, data compiled from both human and nonhuman (mainly rat) studies suggest that classical conditioning ability may emerge within the first few days after birth (Fitzgerald & Brackbill, 1976; Rudy & Cheatle, 1979). Infant rats show the ability to acquire a conditioned aversion (CR) to an odor (CS) that has been paired with an injection of lithium chloride (UCS) as early as two days following birth. Lithium chloride produces nausea and digestive upset (the UCRs). A novel odor introduced shortly before these symptoms appear becomes aversive due to conditioning. The fact that infant animals can form this kind of conditioned response is remarkable, and demonstrates the adaptive plasticity of their behavior. Even more remarkable is the fact that rats as young as eight days can form a conditioned odor aversion with delays of up to ninety minutes between exposure to the odor and injection. Two-day-old rats are unable to tolerate such long CS-UCS delays. This finding suggests a possible developmental increase in duration of memory between the second and eighth days of a rat's life. It also represents an exception to the idea that close temporal contiguity of CS and UCS is always necessary for conditioning to occur. Later in this chapter we will see other evidence that also brings the temporal contiguity notion into question.

Studies have shown that classical conditioning is not easy to demonstrate clearly in newborn humans (Sameroff, 1971), but Kaye (1967) was able to condition newborns to respond with sucking movements (CR) to a tone (CS). This was accomplished by pairing the tone with a pacifier (UCS) that elicited sucking (UCR) when placed in the infant's mouth. There were two major groups of infants: the experimental group, which received tone-pacifier pairings, and a control group, which was exposed to the tone and the pacifier just as often as the experimental group but never to a pair-



The sucking reflex has been used in many studies attempting to demonstrate classical conditioning in infants.

ing of the two stimuli. The results showed that conditioned anticipatory sucking in response to the tone presented *without* the pacifier occurred in the experimental group only.

Other studies have shown that younger infants require a longer interval between presentation of the NS and UCS than older infants for conditioning to occur. Perhaps the younger infant's nervous system requires more time to process or consolidate the stimulus information, due to developmental immaturity. But other than this finding, there is little indication of age-related differences in ease or effectiveness of conditioning in humans.

Alternative Explanations of Classical Conditioning

What happens when a response becomes conditioned to a stimulus? Earlier we said that two relationships are acquired: (1) the conditioned response becomes connected to, or associated with, the conditioned stimulus; (2) the learner associates the conditioned stimulus with the unconditioned stimulus. Not all psychologists hold that both kinds of associations are formed in classical conditioning. In fact, some theorists have argued strongly for the first kind of association, CS-CR, and others for the second, CS-UCS.

The CS-CR Association

The CS-CR connection is the kind of association emphasized in most theories of learning proposed during the first half of the twentieth century. According to this view, the salivation response of Pavlov's dogs, although stimulated initially by meat powder on the tongue, becomes attached to the sound of the clicking metronome. In other words, the dog has substituted the sound of the metronome (CS) for the meat powder (UCS). The dog is considered relatively passive throughout this process, and the cementing of the association between metronome and salivation is believed to be accomplished in an automatic manner. All that is necessary is close temporal contiguity between the CS and the UCS-UCR events. In addition, the bond between CS and CR becomes stronger with increasing numbers of conditioning trials. In summary, according to this view, what is learned is a connection between elements of a physical stimulus (S) and an overt response (R).

The CS-UCS Relationship

The second view of what is learned in classical conditioning, which has received considerable attention in recent years, is that the learner comes to associate the conditioned stimulus with the unconditioned stimulus. This is a stimulus-stimulus (S-S) rather than a stimulus-response (S-R) view of classical conditioning.

Actually, the S-S interpretation is not all that new. At times Pavlov described classical conditioning as follows: the learner comes to recognize the conditioned stimulus as a "signal" for the appearance of the unconditioned stimulus. And later the learning theorist Edward Tolman (1932, 1949) enriched this idea. Tolman argued that what an animal acquires in any kind of learning task is a set of expectancies about the environment. Pavlov's dogs learned to expect the meat powder when they heard the metronome, and then salivated in anticipation of it. This S-S view is considered a *cognitive* explanation of learning; the learner has acquired *cognitions* about the nature of the relationship between the conditioned and the unconditioned stimulus. Note that in this view the learner is assumed to play a more active role, even in a simple classical conditioning task, than is the case in S-R learning.

Tolman's cognitive learning theory did not achieve major status among learning researchers during the 1930s, '40s, or '50s; the S-R view predominated. However, by the early 1970s some of Tolman's ideas had been resurrected, modified and tested experimentally. The modern version of the cognitive view of classical conditioning owes much to the research of Rescorla and his colleagues (Rescorla, 1968; Rescorla & Holland, 1982; Rescorla & Wagner, 1972). They have proposed that subjects in a classical conditioning task learn about outcomes that are contingent upon the occurrence of the CS. According to this interpretation, sometimes called a *contingency* explanation, Pavlov's dogs learned that the sound of the metronome reliably predicted the meat powder. In other words, the dogs learned that the meat powder was contingent upon hearing the metronome.

> Rescorla's claim was straightforward: a CS acquires information value (association or predictive power) concerning whatever event follows it in time. If the outcome of the CS is a [UCS], then the CS provides information about the occurrence of the [UCS]. The animals can use the CS to predict the [UCS] presentation and . . . conditioning occurs. If, on the other hand, the CS is reliably followed by "no [UCS]," . . . then the CS provides information about that outcome. Conditioning still occurs, but the CR is inhibitory in nature. In both cases, then, conditioning is based upon the consistency of the stimulus-outcome relationship or correlation, not just on the number of CS-[UCS] pairings (Tarpy, 1982, p. 40).

Note the cognitive nature of this kind of learning. Animals are not blindly responding to the CS simply because it has been paired frequently with the UCS. Rather, they are somehow acquiring information, forming cognitions about the consequences of the CS presentation. Second, learning is going on even when the CS is presented repeatedly *without* the UCS. Animals learn that *no* UCS follows presentation of the CS.

It appears that animals may be able to learn more than a simple expectation that the UCS will or will not follow the CS. They may well acquire some sense of the *probability* of a UCS outcome. Rescorla (1968) trained rats to press a bar for food rewards. Following this training, a classical conditioning task was introduced in which the CS was a two-minute tone and the UCS was an electric shock. For all of the rats tested the actual probability of receiving a shock while the tone was on was .4. In other words, the UCS followed the CS on 40 percent of the trials during which a CS was presented. However, one subgroup of rats, group 1, also received a shock on 40 percent of the trials in which *no* CS occurred. For group 1, then, the probability of a UCS following the CS was .4, but the probability of a UCS occurring independently of the CS was also .4.

Another subgroup, group 2, received a shock on 20 percent of the trials in which a CS was not presented. Thus, for this group the probability of the UCS following the CS was .4, but the probability of the UCS occurring alone was .2.

A third subgroup, group 3, received a shock on 10 percent of the trials in which a CS was not presented, and a fourth, group 4, received no shocks on the no-CS trials. Thus for groups 3 and 4 the probability of the UCS following the CS was .4, as it was for groups 1 and 2, but the probability of the UCS occurring alone was .1 for group 3 and 0 for group 4.

Following conditioning, each animal was again placed in the bar-pressing situation, and the CS (tone) was presented periodically while the animal was pressing the bar. The UCS (shock) was not presented during this time. If the animals had learned to fear the tone during conditioning, the fear should be elicited when the tone is heard and should interfere with (that is, suppress) the animal's bar-pressing activity. Moreover, if the animals had learned something about the probability of the UCS following the CS, then two major predictions can be made:

1. Group 1 should show little or no disruption in bar-pressing because the probability of the UCS following the CS (.4) is the same as the probability of the UCS occurring without the CS (also .4).
2. Groups 2, 3, and 4 should show increasing amounts of disruption respectively, because the probability of the UCS occurring without the CS ranged from .2 to 0.

The results of the experiment verified these predictions. Animals in group 4 showed the greatest disruption in bar-pressing when they heard the tone, followed by groups 3, 2, and 1, in that order. Thus although animals in all four groups had received the same number of CS-UCS pairings, they did not acquire the CS-CR association to the same degree. They appear to have "compared" the CS-UCS probability (.4) with the probability of the UCS occurring alone. The larger the ratio of the former probability to the latter, the greater was the likelihood that the animals would learn to fear the CS.

Results like these suggest that classical conditioning is not as simple as was once believed. Animals in Rescorla's experiments appear to have learned something more than a CS-CR connection. They seem to have acquired fairly accurate expectancies concerning the probability of a UCS outcome given a CS.

The S-R view of classical conditioning, and indeed of all learning phenomena, dominated the field of learning through the 1950s. The 1970s saw a dramatic shift in emphasis, however. The learner is no longer seen as a passive organism that accumulates S-R connections and not much else; rather, "modern views of learning see the organism as storing information about its world and deriving its performance from that information. Moreover, the organism is increasingly viewed as storing a wide variety of kinds of information and using a broad range of formats for that storage" (Rescorla & Holland, 1982, p. 300).

Classical Conditioning and Survival

Classical conditioning may well be the basis for learning to attach certain physiological and emotional responses to various stimuli. The stimuli may be external to the organism, such as the white rat in the Albert experiment, or internal, such as the taste of a toxic food that has previously produced gastric upset. Classical conditioning, together with instrumental learning (Chapter 8), may play a role in the process of developing close affectional ties between offspring and parents in many species. Children often experience warm emotional responses when they see their mothers, especially if there has been a period of separation. The attachment of such feelings (CRs) to the mother (CS) may have come about in part because the mother has been paired consistently with satisfaction of the child's needs for food, drink, warmth, physical contact, and avoidance of pain. In other words, when someone makes us feel good on a consistent basis, it is not uncommon for us to respond to that person in a loving manner. Of course this is not all there is to the formation of an affectional bond between child and parent, or any other affectional bond, for that matter. But classical conditioning is a learning mechanism that could explain, at least partially, certain aspects of the child's attachment of affectional responses to the parent.

Much has been made of the survival value of affectional ties between parents and offspring in humans (Bowlby, 1958, 1969, 1973) and in nonhumans (see Chapter 8, Supplement 1), although the precise ways in which such ties are adaptive for humans are more matters of speculation than empirical facts (Hay, 1980). At the very least, however, bonding between parents and their offspring promotes physical proximity, which is important for attending to the essential biological needs of offspring and for providing them with protection and a secure base for future development. In some species interference with normal parent-offspring bonding is known to have serious consequences for social development, mate selection, sexual behavior, and parenting behavior of the offspring. To the extent that classical conditioning aids the formation of this important affectional relationship between parent and offspring, it would clearly be an adaptive behavioral capacity.

Classical conditioning is also thought to play a role in the acquisition of aversions to particular stimuli, aversions that generally promote survival. For example, blue jays normally prey on insects, including butterflies. But a particular kind of butterfly, the monarch, contains a toxic substance that can make its predators ill. Blue jays apparently have no way of recognizing monarchs as toxic except through (painful) experience. Some time after consuming a monarch the blue jay becomes ill, and on its next encounter with a monarch will reject it on the basis of taste. After a few more experiences with this butterfly, the blue jay will not even capture it, let alone taste it. It appears that the blue jay acquires a taste aversion to the monarch, and even associates the visual features of this butterfly with the taste-illness association (Brower, 1969).

A monarch butterfly can provide a meal for an inexperienced and hungry bluejay. However, this particular butterfly carries a substance that is toxic to bluejays and will make them ill. Bluejays unfortunate enough to sample monarchs learn to avoid subsequent encounters with them and to avoid nontoxic butterflies that resemble monarchs.

In this example, presumed unpleasant visceral responses (UCRs) were elicited by the monarch's toxin (UCS). As a result, the taste and visual properties of the monarch (CSs) have become capable of eliciting unpleasant visceral experiences on their own (CRs), and therefore lead to avoidance of this particular species by the blue jay. In addition, the blue jay can generalize this avoidance to butterflies resembling the monarch (stimulus generalization), even though they have never been consumed. Obviously this is a very important learning mechanism for the efficient feeding behavior and survival of blue jays, not to mention the survival of the monarch and butterflies resembling the monarch.

Acquired gustatory, olfactory, and visual aversions—based on taste, smell, and sight—have been studied extensively, and they occur in a wide variety of species, including humans. These studies have revealed some fascinating adaptive variations in classical conditioning mechanisms described earlier in the chapter. In particular they question one of Pavlov's basic assumptions about classical conditioning: "Any natural phenomenon chosen at will may be converted into a conditional stimulus [CS] . . . any visual stimulus, any desired sound, any odor, and the stimulation of any part of the skin" (Pavlov, 1957). Some of the difficulties with this assumption and others related to principles of classical conditioning are dealt with in the next section.

The "Garcia Effect"

Imagine the following scenario. You are invited to a friend's house for dinner. Your favorite casserole is served, topped with a sauce you have never sampled before. You thoroughly enjoy the meal and your visit, return home, and retire for the evening. A few hours later you awaken in a cold sweat, feeling nauseated and dizzy. You spend the remainder of the night vomiting and wishing you were dead. By morning you begin to recover, and by the next day things return to normal.

The following weekend you accept another dinner invitation from a different acquaintance. A casserole is the main course again, but a different kind, and also one you have enjoyed in the past. The sauce looks like the new one you sampled last week and enjoyed. You dig in to the casserole, and with the first bite you recognize the sauce to be the one you tried last week. Immediately you become nauseated, and almost reflexively spit out the food.

Although this behavior may not win you any more dinner invitations, it reflects the fact that a highly adaptive kind of *learning* has occurred. This kind of learning—the learning of aversions to particular tastes—has been studied extensively by John Garcia and his colleagues, as well as by many others.

In a now classic series of experiments, Garcia and Koelling (1966) showed that rats are very selective about the particular stimuli that will become CSs when paired with an illness-producing UCS. In one experiment rats were first tested to determine how much of two different kinds of water they would drink. One type of water can be termed "bright-noisy." When the rat drank from the spout of a container, this action completed an electrical circuit that created a flash of light and a clicking sound—thus bright-noisy water. The other kind of water was flavored with saccharine, and we can refer to it as sweet water. After drinking levels had been established for each kind of water, one group of rats drank bright-noisy water and were made ill by being exposed to X-radiation. Another group drank sweet water followed by the same aversive consequence.

Note what happened here in terms of classical conditioning. For one group the bright-noisy water is a neutral stimulus (NS) that is paired with X-radiation (the UCS) and its illness-producing effects experienced some time later (the UCR). For the other group the sweet water is the NS, also paired with X-radiation (UCS) and its effects (UCR). If Pavlov had been asked to predict the outcome of this experiment, he likely would have said that either substance—bright-noisy water or sweet water—should become an effective CS for unpleasurable visceral responses. Therefore, according to this traditional view, both groups of rats should develop an aversion.

However, this was not the case. Following recovery from their temporary digestive upsets, the rats were again tested to determine how much bright-noisy water or sweet water they would consume. Results showed that the rats that had consumed sweet water before they were made ill developed an aversion to sweet water. Rats that had consumed bright-noisy water showed little or no aversion to it, even though they also had been made ill.

In another experiment carried out by Garcia and Koelling, rats drank sweet water that was also bright-noisy (both CSs were combined), and this was followed by an electric shock administered to their paws (the UCS). Following this conditioning they were given either sweet water or bright-noisy water to see how much they would consume. The results with electric shock as a UCS were just the opposite of those just described, in which X-radiation had been the UCS. That is, only the bright-noisy water CS was associated with a significant reduction in drinking following conditioning; the rats formed an aversion to bright-noisy water, but not to sweet water (see Table 7.2).

These results show that rats can learn readily to associate an *external* stimulus, bright-noisy water, with an *external* aversive consequence, electric shock. That is, they quickly learn to reduce their intake of water associated with distinct or novel external (in this case, visual-auditory) cues if previous consumption in the presence of these cues has led to punishment with an externally applied aversive agent. However, if the aversive agent acts internally, as the X-radiation did in producing illness, the animals are less likely to make the connection between the visual-auditory cues and the illness, and thus do not reduce their intake of the bright-noisy water.

TABLE 7.2 Garcia and Koelling's Experiments on Conditioned Aversions

Experiment 1

		Unconditioned Stimulus → *Unconditioned Response*
		X-Radiation → Digestive Upset
Neutral Stimuli	Sweet water	Rats acquire aversion
	Bright-noisy water	Rats do not acquire aversion

Experiment 2

		Unconditioned Stimulus → *Unconditioned Response*
		Electric Shock → Pain
Neutral Stimuli	Sweet water	Rats do not acquire aversion
	Bright-noisy water	Rats acquire aversion

On the other hand, when an *internal* cue, taste, is associated with the water, the effects of shock and X-radiation are *reversed.* Rats quickly learn to reduce their intake of water associated with a distinct or novel internal cue (here, the sweet taste) if the noxious internal effects of radiation have followed the drinking of saccharin-flavored water. Electric shock, an external aversive stimulus, is *not* as effective in establishing an aversion to an internal cue.

Incidentally, it is extremely difficult to establish aversions in rats to *familiar* substances. For example, rats will not learn to associate the characteristics of plain water with aversive consequences.

The rapid and selective learning of aversions such as we have just described is often referred to as the **Garcia effect.** The initial findings of Garcia and his colleagues have been replicated, extended, and qualified. Investigators in this area have shown, for example, that taste aversions can be established in rats with delays of an hour or more between the animal tasting the substance and getting ill (Garcia, Ervin, & Koelling, 1966). In fact, Bolles (1975) cites unpublished data suggesting taste aversions may be learned with delays up to eight hours, although the effect is rather weak with such long delays. It is interesting to note that the Garcia, Ervin, and Koelling study met with considerable disbelief in some quarters because, according to well-established learning principles, conditioning should be impossible with delays that long. Seligman and Hager (1972) cite one example of this skepticism: "One investigator, who had worked for years on delay of reinforcement, remarked publicly, 'Those findings are no more likely than bird-shit in a cuckoo clock,' Nevertheless, they have been replicated many times" (p. 15).

In extending our knowledge of the Garcia effect, other researchers have demonstrated some intriguing species' differences. For example, bobwhite quail readily acquire aversion to the visual characteristics of water when ingestion of colored water is followed by poisoning. Although the quail *can* learn an aversion to taste cues that have been coupled with poisoning, it is easier for them to make the connection between visual cues and illness. Just the opposite is true with rats, as we have seen; *why* this should be the case will be discussed shortly.

Several studies have now shown that it is possible, under certain circumstances, to condition rats to avoid visual or auditory stimuli by using a poison UCS (Tarpy, 1982). However, for rats the fact remains that a connection between taste and illness is learned much more readily than is an association between visual or auditory stimuli and illness (Dickinson & Mackintosh, 1978).

Three major points regarding the Garcia effect should be stressed. First, even within a single species, it is clear that a given aversive stimulus (for example, electric shock) can have very *different* effects on learning, depending on the stimulus with which it is paired (for example, visual-auditory vs. olfactory-gustatory). In order to understand these different effects, we must take into account the characteristics of the species under investigation. Normally rats forage in a number of different places, and their diet, like that of humans, consists of a wide variety of foodstuffs. The natural consequence of eating toxic food is to get sick.* Given their status as generalized eaters, and their heavy reliance on taste and smell as means of perceiving their surroundings (as opposed to vision, for example), any mechanism for readily associating unfamiliar tastes and smells with illness would have high survival value, and would therefore be favored by natural selection.

On the other hand, externally produced pain, such as that resulting from electric shock, is *not* a natural consequence of eating toxic foods. Therefore, a learning mechanism that enabled rats to associate unfamiliar tastes with externally produced pain as readily as with digestive upset would seem to have questionable adaptive value. In other words, rats equipped with such a mechanism would probably not enjoy any reproductive advantage over those not so equipped.

In fact, we might speculate that such a learning mechanism could *reduce* fitness. It is conceivable that, on occasion, rats sampling unfamiliar foods or liquids may be attacked by other rats or by animals of another species, such as dogs or cats. It is also possible that they may be hurt by a trap in the process of eating. These kinds of encounters would likely produce pain via some of the same physiological mechanisms as those that are involved in electric shock. But it might be maladaptive for the rat to learn an aversion to a particular food based on associating its taste with the pain of being bitten or otherwise injured. Such a mechanism would have the rat rejecting a potentially useful food substance, and if stimulus generalization occurred the rat would reject other similar-tasting nontoxic foods as well. It would seem quite adaptive, however, for the rat to be able to learn to recognize the visual and auditory features of the situation in which it had been attacked. The rat could then avoid eating in situations in which physical harm is likely to result. From an evolutionary point of view, it may be no accident that the Garcia effect works the way it does.

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* Rats are known to sample only small amounts of an unfamiliar substance, then wait some time before trying the substance again. This reduces the likelihood that they will become so ill that they die from sampling a toxic food or liquid, and makes it possible for them to in effect profit from experiencing the effects of illness.

The second point regarding the Garcia effect concerns the importance of *temporal contiguity.* Traditional principles of classical conditioning tell us that an unconditioned stimulus must follow the neutral stimulus within an extremely short period to time—typically within a matter of seconds—for conditioning to occur. But the research of Garcia and others has shown that it is possible for animals to acquire taste aversions with relatively long delays between consumption and illness. This makes a great deal of adaptive sense in view of the time normally required for poisons to produce digestive disturbances, which ranges from several minutes to hours. Clearly, rats unable to associate taste cues with illness that occurs much later would be at a distinct disadvantage in terms of survival.

The third and final point about the Garcia effect concerns *species differences and similarities.* Where two species rely primarily on different sensory modalties for coping with the environment, we might expect to see differences in the way they acquire aversions. The results with bobwhite quail and rats cited earlier support this expectation. Given that quail and other birds depend heavily on vision for food selection and consumption, whereas rats sample food on the basis of taste and smell, the fact that quail seem more prepared to associate novel visual cues with illness is not surprising.

We should also expect to see certain similarities among species with respect to the Garcia effect. For example, in a wide variety of species, a time delay is necessary for most toxic foods to produce symptoms of illness. Thus it seems reasonable to expect that many species, including humans, should have evolved the capacity to bridge these lengthy temporal gaps. So far, much of the evidence seems consistent with this hypothesis. It appears that rats, quail, guinea pigs, and garter snakes are able to learn illness-induced aversions with delays of thirty minutes and longer between consumption and illness (Dewsbury, 1978). Anecdotal evidence suggests that humans can learn smell and taste aversions associated with foods that are in fact toxic, or that are eaten sometime prior to symptoms of stomach illness due to a virus. Interestingly, knowledge that food was *not* contaminated does little to change the learned aversion (Seligman & Hager, 1972). There is more systematic evidence that humans can acquire taste aversions to novel food substances that have been ingested prior to induced illness. Ilene Bernstein, for example, found that child and adolescent cancer patients, who received chemotherapy which made them ill, formed aversions to novel-tasting ice cream they had eaten just prior to receiving the treatment (Bernstein, 1978).

The Garcia effect points to variation and complexity in learning that is not easily explained by traditional views of classical conditioning—for example, the idea that all stimuli are equal in terms of their potential effectiveness as CSs, and the idea that temporal contiguity is essential for conditioning to occur. However, the variation and complexity are more understandable when viewed as the results of species-typical adaptations to the natural environment.

8

Instrumental Learning

Measuring Response Strength

Types of Instrumental Learning

Selecting and Establishing the Response

Increasing and Maintaining Response Strength

Elaborating and Refining the Learned Response

Inhibiting an Instrumental Response

The Development of Instrumental Learning

The Adaptive Significance of Instrumental Learning

Observational Learning

The Development of Observational Learning

The Adaptive Significance of Observational Learning

Supplement 1 Imprinting: A Unique Kind of Adaptive Learning

Chapter Preview

Instrumental learning is characterized as behavioral change that occurs because of the consequences or feedback associated with the learner's response. Edward L. Thorndike and B. F. Skinner studied this kind of learning extensively, and both emphasized the importance of the contingent relationships that exist between responses and certain stimuli in shaping behavior. Such stimuli include (1) *positive*

reinforcers, rewarding stimuli that follow a response and increase its likelihood of occurrence in the future; (2) *negative reinforcers,* aversive stimuli that are removed after a response occurs, thereby increasing the likelihood of occurrence of that response in the future; and (3) *punishers,* aversive stimuli that are applied after a response occurs, thereby reducing the likelihood of occurrence of that response in the future. Principles of instrumental learning, like those of classical conditioning, have been used as a basis for effective therapies and other applied training techniques.

Instrumental learning ability appears early in the lives of those species studied, mainly rodents and humans, and does not wane until just before death. However, in some species, including man, there are developmental differences in the content of instrumental learning. That is, *what* can be learned changes with age. There also appear to be age-related changes in *learning efficiency,* and in the *retention* of what is learned.

Traditional principles of instrumental learning can explain, and can be used to modify, a wide variety of behaviors in a number of different species. However, certain behavioral phenomena are not easily explained by such principles. Two instances in particular — *autoshaping* and *instinctive drift* ("the misbehavior of organisms") — constitute important exceptions to traditional rules of instrumental learning. Both of these phenomena call into question the generality of the *law of effect,* which states that responses must be reinforced for efficient instrumental learning. They also call into question the traditional distinction made between classical conditioning and instrumental learning, and the assumption that the nature of the particular response selected for conditioning, or the stimulus used, is irrelevant to understanding the mechanisms of instrumental learning.

Observational learning is learning through imitation, and is often considered a type of instrumental learning. However, observational learning is quite distinctive in certain respects. For example, it can occur without practice, without any apparent external reinforcers, and with long delays between observing the actions of others and performing those actions. Much of what we know about observational learning is based upon the work of Albert Bandura, who has hypothesized that four processes govern observational learning: attention, retention, motor reproduction, and reinforcement and motivation.

The ability to learn by observing others plays an important role in survival, but different species rely on observational learning to varying degrees. This is especially evident in the song learning of certain species of birds. Certain kinds of observational learning occur more readily during particular periods of development, called sensitive periods. This is true of song learning in the white-crowned sparrow and may be true of human language learning as well.

The supplement to this chapter discusses imprinting, a distinctive kind of learning that involves the formation of an attachment, usually to the parent, as a result of experience during a sensitive period. Imprinting is easily observed in many species of birds, but occurs in certain other animals as well.

Learning by "trial and error" is referred to in psychology as **instrumental learning.** It has been characterized as behavioral change that comes about because of the *consequences* or *feedback* associated with the learner's responding. It is called *instrumental* because the learner's behavior is instrumental in bringing about desired consequences, such as the attainment of a reward or the avoidance of a punishment. Like classical conditioning, instrumental learning involves responses and stimuli and the acquisition of relationships among them. However, the response to be modified in instrumental learning usually is not an automatic reflex elicited by a stimulus, as it is in classical conditioning, but a behavior that is subject to a greater degree of *voluntary control.*

The American psychologist Edward L. Thorndike usually is credited with the first laboratory studies of instrumental learning, which he published in 1898. Thorndike had cats attempting to escape from "puzzle boxes" in order to obtain food that was located just outside the box (Figure 8.1). Thorndike considered the *stimuli* to be characteristics of the box, especially those devices that could be used to open the door. For example, as you can see in Figure 8.1, a pulley connected a pedal inside the box to a sliding bolt. If the cat stepped on the pedal, the bolt retracted and the door opened. The cat could also manipulate either of the bars that held the door in place. A number of other solutions were also possible for solving the "puzzle," and Thorndike considered these solutions the *responses* of interest. As the cat gained experience over successive trials, there was a decrease in the time required to discover the correct response and escape from the box. As you might expect, Thorndike also observed that the cat made fewer errors with increased practice. This kind of study was repeated with other puzzles, runways, and mazes, and with other animals (Figure 8.2).

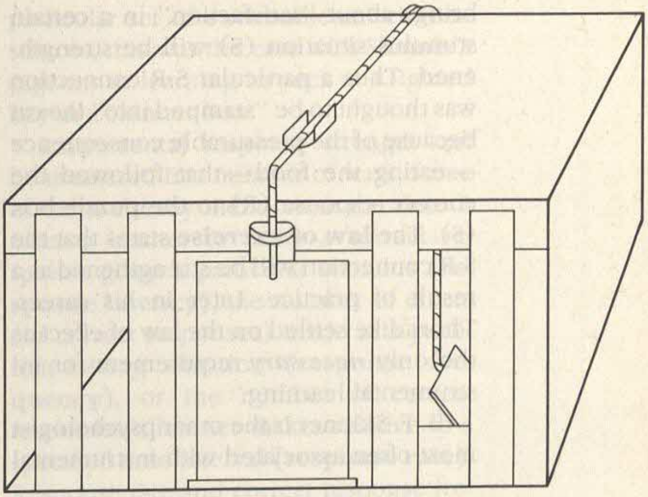
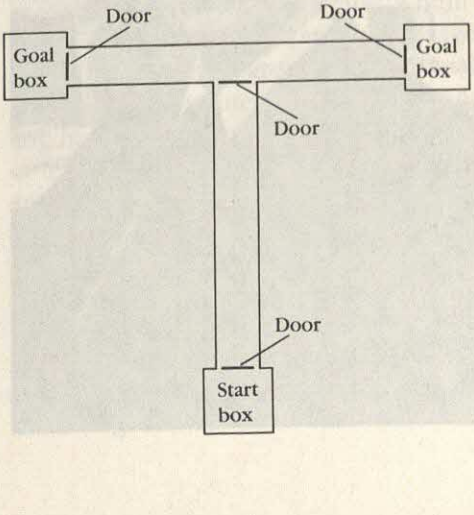


FIGURE 8.1 A puzzle box apparatus for investigating instrumental learning.

Thorndike proposed two "laws" to account for his findings, the law of effect and the law of exercise. The **law of effect** states that any response (R) that

FIGURE 8.2 The T-maze, a commonly used apparatus for studying instrumental learning in animals, especially laboratory rats.



brings about "satisfaction" in a certain stimulus situation (S) will be strengthened. Thus a particular S-R connection was thought to be "stamped into" the cat because of the pleasurable consequence —eating the food—that followed the correct response (R) to the puzzle box (S). The **law of exercise** states that the S-R connection will be strengthened as a result of practice. Later in his career, Thorndike settled on the law of effect as the only *necessary* requirement for instrumental learning.

B. F. Skinner is the other psychologist most often associated with instrumental learning. Skinner's work is of contemporary as well as historical significance, and his influence certainly has exceeded the boundaries of psychology. He is perhaps best known to the lay public for his utopian novel *Walden Two* (1948), which describes an ideal society that was based on an application of laboratory-derived principles of instrumental learning.

B. F. Skinner has been one of the most influential psychologists of the twentieth century. He is famous for his studies of operant conditioning, a widespread form of learning, and for his behavioristic perspective in psychology.

Skinner coined a different term for instrumental learning; he called it **operant conditioning.** The term *operant* suggests that the learner's behavior operates on, or has an effect on, the environment. This effect is a consequence of behavior, and is what changes the probability that the behavior will occur again. For example, a child cleans up her room (a behavior) and is praised by her mother for doing so (a consequence). The behavior has operated on the environment by leading to a rewarding consequence, one that will serve to make room cleaning more likely to occur in the future. Note that the basic principle underlying operant conditioning is similar to Thorndike's law of effect—any response that results in a satisfying consequence will tend to be strengthened.

The term *operant* also has come to imply a certain set of procedures for investigating instrumental learning phenomena. Skinner introduced a special apparatus for studying instrumental learning in nonhumans. It differed somewhat from Thorndike's puzzle box, and did not at all resemble the various runways and mazes other psychologists have used. The apparatus has been called, affectionately, the "Skinner box" (Figure 8.3). Researchers using the Skinner box select a single response for conditioning, such as pressing a bar for rats, or pecking a lighted target (response key) for pigeons. Learning is assessed by noting changes in the *rate of responding,*

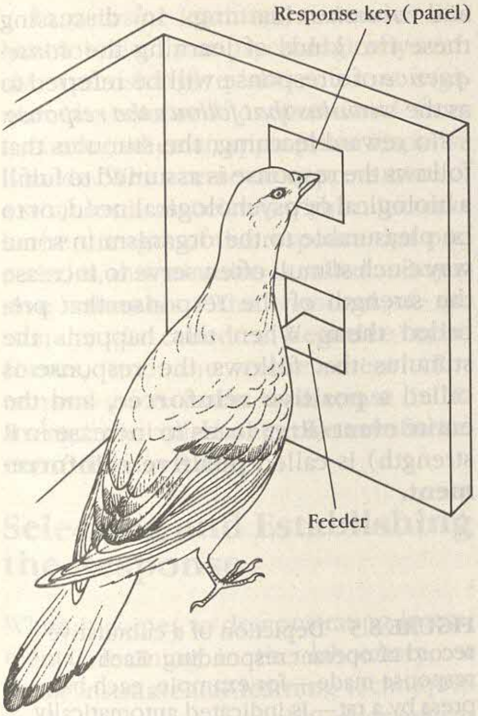


FIGURE 8.3 Cutaway view of a Skinner box designed to reinforce the pecking response of pigeons. When the bird pecks the response key, food is made available in the feeder.

the number of responses made during a particular time interval.

Measuring Response Strength

The strength of a given response may be nil prior to learning, in which case instrumental learning consists of acquiring a *new* response; this was the case with Thorndike's cats in learning the responses necessary to escape from the puzzle box. Or it could be that the learner already knows how to perform a particular response, and instrumental learning procedures are used to get that response to occur more often under a particular set of environmental circumstances; this was the case with Skinner's pigeons in learning to peck at a lighted key in a Skinner box.

Instrumental response strength can be measured in a number of ways, some of them already mentioned: the time it takes a learner to make a correct response given a particular stimulus **(response latency),** the number of errors (or correct responses) made in a problem-solving situation **(response frequency),** or the number of correct responses a learner makes relative to a specified time interval **(response rate).** Response rate and correct response frequency are expected to increase if learning has taken place; response latencies and error frequency should decline.

There are very few instrumental learning experiments that utilize all of these response measures. Usually only one measure is used. Psychologists who investigate instrumental learning in the Thorndikian tradition typically use response frequency or latency, or both. Such experiments involve many repetitions (trials). On each trial the experimenter gives the subject an opportunity to solve the problem — make a correct turn in a maze, get out of a puzzle box, recall a prose passage studied previously, and so forth. Generally, a number of subjects are tested and the average performance for the group is plotted trial by trial to determine whether any learning has taken place (Figure 8.4).

Psychologists who investigate learning in the Skinnerian tradition typically use response rate as a measure of response strength. Generally there are no discrete trials. The subject is placed in the learning situation (a Skinner box or classroom, for example), and performance is monitored continuously over time (Figure 8.5).

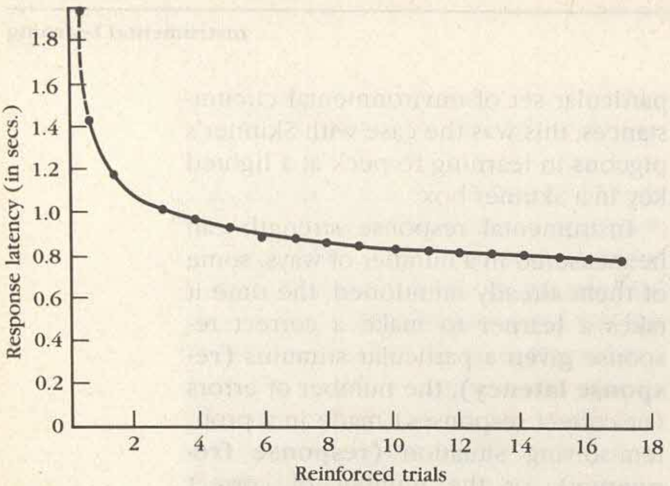


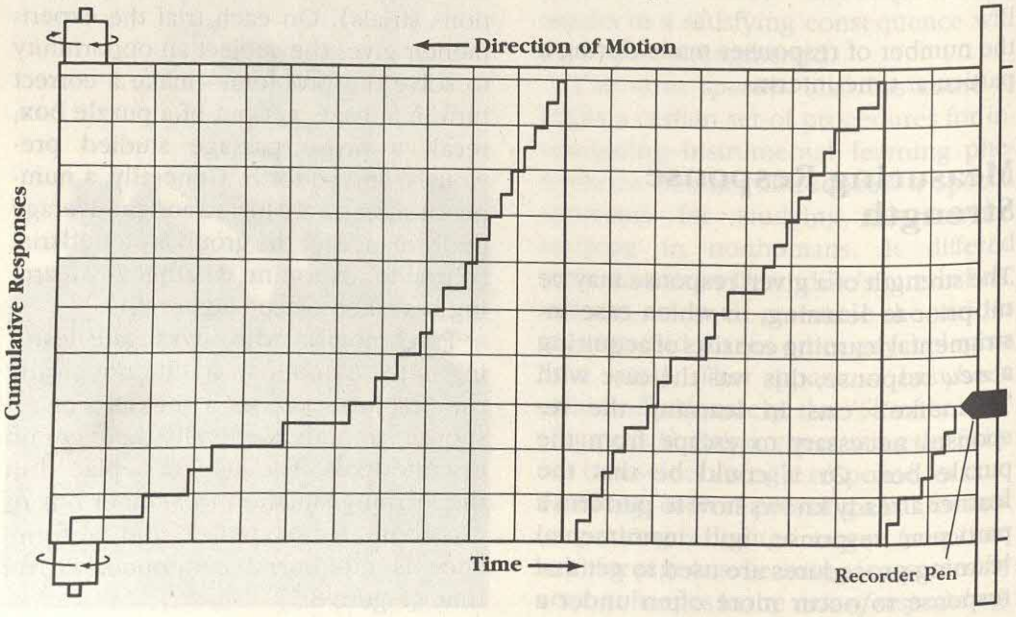
FIGURE 8.4 Instrumental learning curve showing a gradual decline in the latency of a response as a function of reinforced trials.

Types of Instrumental Learning

It is useful to subdivide instrumental learning into two major types according to the nature of the consequence the response brings about: *reward* learning and *aversive* learning. In discussing these two kinds of learning the *consequence* of a response will be referred to as the *stimulus that follows the response.*

In reward learning, the stimulus that follows the response is assumed to fulfill a biological or psychological need, or to be pleasurable to the organism in some way. Such stimuli often serve to increase the strength of the response that preceded them. When this happens the stimulus that follows the response is called a **positive reinforcer,** and the entire event (R→S leads to increase in R strength) is called **positive reinforcement.**

FIGURE 8.5 Depiction of a cumulative record of operant responding. Each response made—for example, each bar press by a rat—is indicated automatically by an upward vertical deflection of a pen on a chart recorder called a cumulative recorder. Paper on the recorder moves past the pen at a constant rate. If no response is made, the pen records a horizontal line.



In *aversive* learning, a stimulus that has biologically or psychologically aversive (punishing) qualities for an organism is removed or prevented from occurring when an appropriate response is made. When removal or prevention of a stimulus is associated with an increase in the strength of the response that preceded it, that stimulus is called an **aversive stimulus.** The *removal* of the stimulus is called a **negative reinforcer,** and the entire event (R→ removal of S leads to increase in R-strength) is called **negative reinforcement** (Figure 8.6).

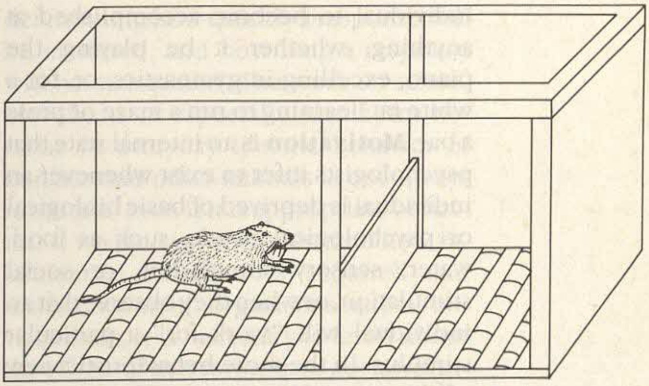


FIGURE 8.6 A shuttle box, used in studies of aversive learning. The floor on one side of the partition can be electrified. In this situation, electric shock to the rat's paws is an *aversive stimulus.* Jumping the hurdle removes the aversive stimulus and is therefore a reinforced *response.*

Selecting and Establishing the Response

When it comes to demonstrating instrumental learning in the laboratory, or using instrumental learning techniques to change behavior in clinical or educational settings, we are confronted with two immediate problems. First, which response should be selected for modification? And second, how do we get that response to occur so that it can be reinforced repeatedly and a change in behavior can be observed?

In demonstrations or applications of instrumental learning principles, it is necessary to select a response that the learner is capable of making. A rat will never learn to fly, and it is highly unlikely that a child with a profoundly subnormal IQ will ever acquire a working knowledge of algebra. And even though an individual is capable of making a particular response, this is no guarantee that the response can be modified using the same principles of instrumental learning. For example, hungry laboratory rats learn to press a bar for food, but it is extremely difficult for them to learn the same bar-pressing response in order to avoid the onset of an electric shock. Similarly, pigeons learn to peck at a lighted key for a food reward, but it is nearly impossible for them to learn to peck a key to avoid shock. These and some other variations in instrumental learning will be explained later in the chapter, although you might want to do a bit of speculating on your own at this point. For now it is sufficient to emphasize that a given response may be modified more easily when it is followed by one kind of stimulus than by another.

Even though we decide to modify a response the individual is capable of making, this does not guarantee that the response will occur when we want it to. There are, however, a number of things that can be done to increase the likelihood that the desired response will occur. These include increasing the learner's *motivation, structuring* the learner's *environment, adapting* the learner to the environment, and *shaping* the response.

Motivation Everyday experience tells us that motivation is necessary for an individual to become accomplished at anything, whether it be playing the piano, excelling in gymnastics, or, for a white rat, learning to run a maze or press a bar. **Motivation** is an internal state that psychologists infer to exist whenever an individual is deprived of basic biological or psychological needs, such as food, water, sensory stimulation, or social stimulation, or when they observe that an individual will "work for" a particular stimulus. In the more behavioristic view of Skinner and his associates, motivation is simply a term used to indicate that a particular stimulus functions as a reinforcer of behavior. Whichever way you want to think of it, it is clear that "motivated" organisms are generally more likely to make responses that can be reinforced than are unmotivated ones.

Environmental Structuring When a psychologist tries to condition a rat to press a bar, a pigeon to peck at a lighted key, or a hyperactive child to sit still and listen to a set of instructions, the immediate environment of the learner can make the desired response, or an approximation of it, either more or less likely to occur at the outset of the task. The hyperactive child should be placed in a setting as free from distractions as possible in order to make it more likely that he or she will sit still long enough to get reinforced and will attend only to information relevant to the task. Likewise, a rat will be more likely to press a bar, even accidentally, if it is close to the bar. The apparatus most commonly used in bar-pressing experiments, the Skinner box, is small enough to ensure close proximity to the bar.

Adaptation An individual who is not adapted to the learning environment—laboratory room, maze, Skinner box—will be less likely to make the desired response. This is probably because the learner will tend to be afraid of or curious about the strange surroundings, and these reactions may compete with the desired response. If a pigeon is to learn to peck at a lighted key in a Skinner box, it is first necessary to allow the bird time to adjust to its new surroundings. In particular, the bird must *habituate* to the sounds made by the automated feeder used for reinforcing pecking behavior. The sound of the feeder is aversive to the pigeon when encountered the first few times. Often it provokes wing flapping and ruffling of the feathers, indicators of emotional arousal. Unless the bird is allowed to habituate to this aspect of the learning environment, the desired response of pecking at the key is unlikely to occur.

Shaping The reinforcement of *successive approximations* of the desired response is called **shaping.** If the learner is not likely to perform the desired response correctly at the beginning of the training session, then approximations of that response may be reinforced in a gradual fashion.

Shaping has been used very effectively in teaching language to some severely disturbed children who, when left untreated, make only nonsensical vocal utterances. In shaping this behavior the sounds are formed into words, first by reinforcing *any* sounds made, next by reinforcing sounds that may bear only the slightest resemblance to the words being taught, then by reinforcing *only closer approximations* of those words, and finally by withholding reinforcement until the child says the word or words correctly. Of course, shaping is only necessary if the desired response is not part of the individual's normal or usual repertoire. For example, it usually is not necessary to shape a rat to run a maze because both running and exploring are normal survival activities for rats in their natural environments. Pressing a bar or lever, on the other hand, is not a normal or necessary response for the rat, and so it should not be too surprising that shaping *is* necessary if a rat is to learn to press the bar.

Although we have described the major ways of making the first occurrence of a desired response more likely, other procedures have been used successfully for the same purpose, especially in instances of human learning. **Prompting** consists of leading the learner through the mechanics of the response, such as placing a spoon full of food in a baby's hand and then guiding its arm so the food reaches the mouth. Another way to prompt a response is to supply a cue for the response, not unlike a prompter offstage providing an actress with a visual cue for her next line. **Modeling** simply means acting out the response for the learner in the hope that the learner will imitate it. We will have more to say about modeling later in the chapter.

Increasing and Maintaining Response Strength

Studies of instrumental learning have demonstrated some very orderly phenomena regarding the acquisition and maintenance of a response. These phenomena have to do with the regularity with which a behavior produces consequences, particularly rewarding (positively reinforcing) consequences. Basically, psychologists have shown that the *schedule of reinforcement* the learner encounters can be important in determining how quickly a response will be mastered, and how long a response will be maintained. The work on schedule effects is especially significant because in everyday life the behavior of humans and other animals is not always rewarded, even if it is appropriate behavior. If we are ever to understand how instrumental behavior is acquired and maintained in an organism's natural environment, it is necessary to know about the effects of *intermittent* or *partial* reinforcement. In addition, in order to design teaching environments that are effective and efficient, whether in the school, clinic, or home, it is imperative to understand the effects of various schedules of reinforcement.

Continuous Reinforcement

Reinforcing responses according to a 1 : 1 ratio, where every correct response is followed by a reinforcer, is called a **continuous reinforcement schedule,** abbreviated **CRF.** Sometimes the frequency of a response under CRF will increase dramatically in a very short period of time, usually faster than responses that are reinforced only intermittently. However, responses that have been reinforced continuously typically decline faster than those reinforced partially during *extinction* trials when reinforcement is no longer forthcoming (Figure 8.7). Recall that extinction in classical conditioning involves inhibiting a conditioned response. In Pavlov's experiments this was accomplished by withholding the unconditioned stimulus (the meat powder) when presenting the conditioned stimulus (beating of the metronome). The result was a gradual decrease in the strength of the conditioned response (salivation). Extinction procedures in instrumental learning are

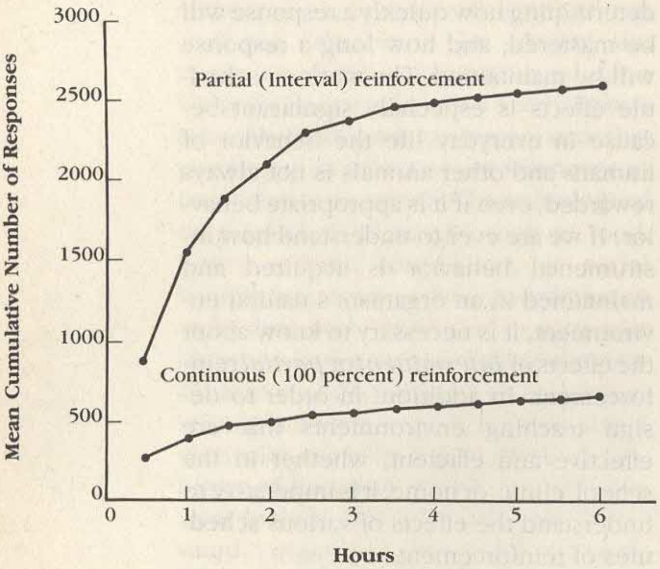


FIGURE 8.7 Responses learned under a continuous reinforcement schedule extinguish much more rapidly than those learned under partial reinforcement. The data in the graph represent responses that are no longer being reinforced.

similar, except that the stimulus withheld is the reinforcer that was originally used to establish or modify the instrumental response.

Partial Reinforcement

Reinforcing responses in a ratio of less than 1 : 1, or only after the passage of a specified amount of time, is called a **partial reinforcement schedule (PRF).** Responses originally reinforced under PRF schedules take longer to extinguish than those reinforced under a CRF schedule. This suggests that response strength—actually the strength of the associations formed between the response and the stimuli—is greater under the partial schedule. But this runs counter to Thorndike's law of effect and to other reinforcement accounts of learning. According to these traditional notions, the more reinforcements, the stronger the response. So what accounts for the partial reinforcement effect on extinction?

One explanation suggests that the learner may acquire different expectancies depending on the particular schedule of reinforcement used during the acquisition phase of instrumental learning. Under PRF the learner expects to be reinforced only part of the time; some correct responses are not reinforced. Now what will happen when the PRF learner is confronted with an extinction procedure in which no instance of a correct response is reinforced? We might anticipate that the learner would continue to make correct responses for some time, even though reinforcers are no longer forthcoming. Why? Because the PRF learner would have become used to receiving no reinforcement for correct responses some of the time during acquisition. Thus the extinction procedure may not differ drastically from the partial reinforcement schedule used during acquisition.

On the other hand, under CRF the learner expects to be reinforced *every* time a correct response is made. Switching the CRF learner to an extinction procedure would, therefore, represent a much greater change than would placing a PRF learner on extinction. It is possible that CRF learners become more frustrated during extinction than PRF learners, because their expectancies about reinforcement have been violated to a greater extent. This may account for the more rapid decline in responding for CRF learners when placed on extinction.

We have discussed partial reinforcement in very general terms. There are a number of different kinds of partial reinforcement schedules, and these have been studied extensively by Skinner and his associates. They apply mainly to situations in which *response rate,* rather than the time taken to run a maze or the number of errors made, is used to measure learning.

There are two major kinds of partial schedules, *ratio* and *interval,* and each of these can be either *fixed* or *variable.*

In ratio schedules the reinforcer is contingent on the learner making a certain number of responses. In a **fixed ratio (FR) schedule** the reinforcer is always delivered after the same number of responses. For example, if a pigeon were on an FR-6 schedule for pecking at a key, it would mean that the reinforcer would be given after every sixth peck. In a **variable ratio (VR) schedule** the reinforcer comes after varying numbers of responses. A VR-6 schedule would mean that our pigeon would be reinforced after an *average* of six responses had been made: sometimes the reinforcer would be delivered after three pecks, sometimes after ten pecks, and so on. However, over a large number of responses, the reinforcer-response ratio would average out to be 1 : 6.

In *interval* schedules the reinforcer is available only after a certain amount of time has passed, and the learner must then make a correct response to receive the reinforcer. In a **fixed interval (FI) schedule** the reinforcer is given only after a set amount of time has passed. So if we switched the pigeon to an FI thirty-second schedule, it would mean that the bird could "earn" a reinforcer every thirty seconds. In a **variable interval (VI) schedule** the reinforcer comes after varying time intervals, but just as with VR schedules, these intervals average out to a certain value.

The interesting thing about these different schedules is that they produce different patterns of response that are quite orderly. Generally speaking, variable schedules produce more stable rates of response than fixed schedules do. This may be due to the fact that the learner cannot predict when reinforcement will be delivered under the variable schedules.

Consider an example that may be more meaningful to you than pigeons pecking lighted keys. An instructor in one of your courses gives a quiz every Friday, while in another, equally difficult course you may be tested anytime. The response we are interested in is studying, and the reinforcer could be considered the attainment of a good grade (a positive reinforcer), or perhaps the avoidance of a failing grade (a negative reinforcer). If you are like many students, your studying behavior for the randomly scheduled quizzes (a variable interval schedule) will probably be better distributed throughout the week than that for the Friday quizzes (a fixed interval schedule). The differences in studying might look something like the curves in Figure 8.8. These curves show the *cumulative* number of responses plotted against time for each schedule of reinforcement. Note the distinctive "scalloping" of the response curve under the FI schedule. In our example this would indicate low amounts of study time during the initial part of the week, but increased amounts as quiz time approaches. This pattern of responding is often associated with FI schedules, and seems to generalize quite well across learning tasks and across species. It is as if the delivery of the reinforcer serves as a cue for the learner to relax, and not waste any effort until the time of the next delivery.

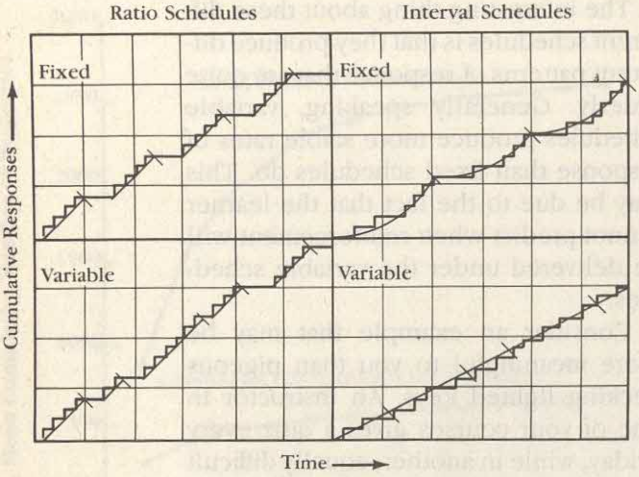


FIGURE 8.8 Cumulative records showing the response patterns associated with four different partial reinforcement schedules. Each "step" indicates a response. The diagonal slashes show when a reinforcer is delivered. Note that in the ratio schedules responding occurs in bursts. There is a scalloped effect in the record of fixed interval reinforcement, and a very steady rate of responding with the variable interval schedule.

Elaborating and Refining the Learned Response

The discussion of classical conditioning in Chapter 7 noted that already conditioned responses can be elicited by stimuli other than the original CS through stimulus generalization and higher-order conditioning. Conversely, responding can be made more selective through discrimination training. Similar principles apply to instrumental learning phenomena. These include *stimulus generalization* and *secondary reinforcement* for elaborating the response, and *discrimination* for refining it.

Just as in classical conditioning, instrumentally learned responses *generalize.* A learned response is more likely to be made in situations that closely resemble the original learning environment than in less similar situations. An aspect of the learning environment, such as the pedal in Thorndike's puzzle box, the bar in a Skinner box, or a particular teacher in a classroom, is called a **discriminative stimulus** (S^D). If the learner encounters a new stimulus that is very similar to an original S^D, it is likely that the learner will continue to make the same responses that were learned and reinforced in the original learning environment.

Secondary reinforcement in instrumental learning resembles higher-order conditioning in classical conditioning. The idea is that stimuli that are present when a behavior is reinforced during acquisition can take on reinforcing properties themselves. In other words, because S^D's have been paired with reinforcement of a particular behavior, they can be used to reinforce that behavior or possibly other behaviors.

Praise is often considered a secondary reinforcer. The words a parent uses to praise a child may be reinforcing because the parent has used them while rewarding the child in other ways in the past. For example, mother may have said "good girl" while feeding or holding her infant daughter. Initially, the words "good girl" may have been a relatively neutral stimulus. But after it has been paired consistently with primary biological reinforcers such as food and comfort, the phrase "good girl" may function as a positive reinforcer. Other examples of potential secondary reinforcers are money, medals, university degrees, passing grades in school, approval from friends, and an approving nod from an instructor. The fact that these things can reinforce behavior is attributed to their association with more basic reinforcers.

Discrimination in instrumental learning is quite similar to discrimination in classical conditioning. It occurs whenever an instrumental response is reinforced (or punished) in the presence of one stimulus but not in the presence of another. Thus, an individual learns to recognize those aspects of the environment that predict reinforcement or punishment of particular responses.

Instrumental discrimination learning would seem to account for much of the learning that occurs in a variety of species under natural conditions. For example, in human learning a number of stimuli must be discriminated when a child learns to read—letters, words, and combinations of words. The reader must learn to make a particular response in the presence of a given stimulus, and not to make it in the presence of a different stimulus. For example, a *b* must be called "bee" and a *d* must not be called "bee." This discrimination is particularly difficult for young children because *b* and *d* differ only in orientation.

How does a child eventually master such discriminations? The task can be thought of as involving elements of instrumental discrimination learning. If the child says "bee" for *b*, he or she receives positive reinforcement; for example, the teacher says "Correct" or "Good." If the child says "dee" for *b*, there is no positive reinforcement, and there may be punishment, in the form of criticism ("No, that's wrong"). Eventually the correct discrimination is acquired.

Learning to read is but one example of instrumental discrimination learning in humans. In many other species, discrimination learning may be involved in recognizing the probable locations of food, predators, competitors, and mates. In some species it undoubtedly plays a major role in recognition of parents and other individuals, as well as in identification of the status of a given individual within a group.

Receiving a diploma might be considered an instance of secondary reinforcement, assuming the scholarly behavior that preceded this event increases or continues at a high level. The diploma would be a secondary, rather than primary, reinforcer because it has no biological reinforcing value in itself. People *learn* to value academic recognition.

Inhibiting an Instrumental Response

As in classical conditioning, two major ways of inhibiting an instrumental response are extinction and counterconditioning. *Extinction* refers to the gradual decline of an instrumental response as a result of withholding the reinforcer, positive or negative. *Counterconditioning* involves establishing a new instrumental response that is incompatible with the unwanted response. For example, some infants tend to cry a great deal more than others, even though they are in good health and are well attended to by their parents. In some cases parents may inadvertently reinforce the crying by being overly responsive to it. In such cases, one way of reducing excessive crying might be to reinforce a response that is incompatible with crying. For example, to smile and cry at the same time is difficult, to say the least. If parents reinforce as many instances of smiling as possible in their child, it is conceivable that the child's smiling would increase in frequency. Because of the incompatibility of smiling with crying, crying frequency should decrease. In fact, reduction of crying in infants by counterconditioning of the smiling response has been demonstrated (Wahler, 1967).

A third way of inhibiting an instrumental response is by using *punishment* — following a response with an aversive stimulus. Successful punishment training inhibits the response that preceded the aversive stimulus. Punishment should not be confused with negative reinforcement, a term we introduced earlier in connection with aversive learning. Negative reinforcement strengthens a response because an aversive stimulus is *removed* when the response is made. For example, a rat learns to jump a hurdle (the response) because such responding turns off an electric shock transmitted through the floor of the cage (the aversive stimulus). Remember, the term *reinforcement* always implies a *strengthening* of the response; the term *negative* refers to the fact that the aversive stimulus has been *removed,* or negated, following an occurrence of the appropriate response. With punishment the response is *weakened* since an aversive stimulus is *presented* following the response.

TABLE 8.1 Effects of Intensity and Timing of Punishment on Suppression of a Response

		Intensity of Punishment	
		Low	*High*
Timing of Punishment	*Immediate*	Intermediate Suppression	Greatest Suppression
	Delayed	Least Suppression	Intermediate Suppression

Punishment can be the quickest and most effective means of inhibiting an instrumental response. Generally speaking, the more intense the aversive stimulus, and the sooner it follows the unwanted behavior, the more effective it will be in reducing or eliminating the behavior. If the aversive stimulus is very intense, but not applied immediately after the unwanted behavior, it still may be effective. Likewise, an aversive stimulus that is not so intense but is applied immediately still may be effective. But if punishment is both intense and immediate, it may eradicate the behavior rather than merely inhibit it (Table 8.1).

Under natural conditions, as in a home environment, punishment usually is neither extremely intense nor used consistently. Developmental psychologists have found that even mild punishment can be effective in reducing unwanted behavior if it is applied at the *outset* of the behavior, or while the behavior is in progress. Punishment seems most effective with children when it is administered rarely, and by an adult who otherwise rewards and nurtures the child. Explaining the reasons for punishment can also increase its effectiveness (Liebert & Wicks-Nelson, 1981).

Although punishment can suppress behavior, it can also have undesirable side effects. Rather than eliminating an unwanted act, punishment may simply teach an individual when not to engage in that act. A child who has had his hand slapped for taking cookies from the cookie jar may never repeat this act in the future, or may simply do it only when his parents are not around.

The repeated use of intense punishment as a mode of discipline may suppress certain unwanted behaviors, but also may elicit others that are equally undesirable. A painful stimulus can be considered an aversive unconditioned stimulus that elicits unconditioned fear responses. These would include physiological components of fear, such as increased heart rate and blood pressure, irregular breathing, and sweating. Through *classical conditioning* such fear responses could become associated with various stimuli, including the persons who do the punishing. For example, a girl who is punished regularly in a harsh manner may learn to respond with fear to the mother doling out the punishment. In this case the mother becomes the conditioned stimulus for fear because of her association with the aversive unconditioned stimulus. The child also may *generalize* this acquired fear to other adults or situations. Thus the repeated and prolonged use of harsh physical punishment may well produce a conforming individual, but also one who is overly fearful and perhaps hostile.

The Development of Instrumental Learning

In those species that have been studied — mainly rodents and humans — the ability to modify behavior as a result of rewarding or punishing consequences seems to be characterized more by *stability* over time than by significant age-related changes. In other words, there seem to be few clear-cut instances of developmental differences in the basic ability to learn in a trial-and-error fashion. Psychologists have demonstrated instrumental learning very early in the lives of the animals they have studied. For example, instrumental reward learning has been demonstrated in laboratory rats as young as seven days of age (Kenny & Blass, 1977), in puppies during the first week of life (Stanley, Bacon, & Fehr, 1970), and in human newborns (Sameroff, 1968; Siqueland & Lipsitt, 1966), using feeding-related responses and reinforcers. Instrumental aversive learning has been documented in rats as young as two days using an unpleasant odor as the negative reinforcer (Rudy & Cheatle, 1979), and in mice as young as five days using electric shock as the negative reinforcer (Nagy, 1979). The ability to engage in instrumental learning, at least in simple tasks, also seems to remain intact throughout life in rodents and humans (Elias, Elias, & Elias, 1977).

Although evidence exists for instrumental learning over a wide age range in the species mentioned, there are nevertheless notable differences in the *content, efficiency,* and *retention* of such learning, differences that are related to development. Some of these differences are rather obvious and do not require psychological research to document. For example, a child of twelve months is unable to learn how to operate an automobile, even one tailored to its size. And a preweanling rat is highly unlikely to learn to traverse a complex maze, no matter how many opportunities it has to acquire the necessary information or how powerful the reinforcer. Finally, it is clear that most people have more difficulty remembering things they experienced as infants and preschoolers than those experienced as school-age children, adolescents, and adults. Exceptions are motor skills, language, and other well-practiced behaviors.

Other developmental differences in instrumental learning content, efficiency, and retention are not so obvious. For instance, preweanling rats typically take longer to acquire a passive avoidance response than do older rats (Campbell & Coulter, 1976). **Passive avoidance** learning is a type of aversive learning in which an animal learns to *inhibit* a response that has been followed by an aversive stimulus. If a child is punished for kicking the family's pet cat, and thereafter inhibits such kicking, this is an instance of a learned passive avoidance response. The child has learned to be passive with respect to hitting the cat, and in so doing *avoids* getting yelled at or being spanked. A rat may learn to inhibit running from one chamber of a cage to another if doing so in the past was associated with receiving an electric shock while in the "wrong" chamber. This would be another instance of passive avoidance learning. (You may also recognize these as instances of punishment, which they are.) At any rate, researchers have shown that this kind of learning is harder for immature rats than for older ones. Many parents might be tempted to believe that very young children also have a more difficult time learning to refrain from doing something than older children do, although this has not been demonstrated scientifically. Why such a developmental sequence should occur is not entirely clear. Some investigators have suggested that young rats' difficulty in passive avoidance learning may be a result of an immature nervous system. The brain's inhibitory functions are not well established at birth in rats or humans, and there is a great deal of nervous system development yet to come. Another possibility is that inhibitory control by the brain is adequate even in very young organisms, but that the *motivation* for making the *active* response that is to be punished is stronger for young animals than for older ones (Campbell & Coulter, 1976).

Age-related changes in the ease of acquiring passive avoidance responses are an example of developmental differences in the *content* of instrumental learning. Now let us consider an example of developmental differences in the *efficiency* of instrumental learning.

Hans Papoušek, a Czechoslovakian researcher of learning capacities in human infants, has carried out a series of studies bearing on the issue of efficiency (1967). Papoušek attempted to condition infants in three age groups—newborns, three-month-olds, and five-month-olds—by reinforcing them with milk for a head-turning response toward the left. Infants had to make five consecutive head-turning responses within a session in order to satisfy the criterion for conditioning established by Papoušek. The newborns required an average of 177 trials to reach criterion, the three-month-olds required 42 trials, and the five-month-olds required only 28 trials. The older the infant, the more efficient the learning.

It is tempting to conclude simply that rapid development of the nervous system, and therefore of learning ability, is responsible for this age-related trend in instrumental learning efficiency. However, things are often not as simple as they appear when it comes to explaining behavior. There were undoubtedly nonlearning differences among Papoušek's groups of infants that could have accounted for his results. It is difficult to imagine that the three age groups did not also differ in sensory and perceptual capacities, attention level and span, motivation, and activity level. And one disturbing difference among these age groups does not depend on imagination or speculation, but rather has been documented scientifically. It is the fact that newborns have a strong bias toward making head-turning responses toward the *right* (Papoušek, 1959; Siqueland & Lipsitt, 1966). The fact that Papoušek demanded *left* head turns of all subjects may have posed particular problems for the newborns, while older infants may have been less likely to make right head turns in the first place.

The third area of developmental differences in instrumental learning is *retention* of what is learned. Studies using rats and mice have shown rather consistently that younger animals show poorer retention of aversive learning experiences than older animals. The older the rat or mouse at the time of learning, the longer it is likely to remember what it has learned. This developmental trend does not appear to be due to differences in level or accuracy of initial learning. It is possible, however, that younger animals are less able to retrieve what they have learned from memory. Or perhaps younger animals store different aspects of information than the older animals. Most researchers agree that "infantile amnesia" is probably related strongly to the immaturity of the nervous system. In this regard, it is noteworthy that guinea pigs, whose nervous systems are much more advanced at birth than those of preweanling rats, do not show developmental differences in retention of instrumental learning (Spear & Campbell, 1979).

Jane Goodall, noted for her naturalistic observations of chimpanzees, has witnessed instances of apparent instrumental learning among chimps in the wild.

The Adaptive Significance of Instrumental Learning

Instrumental Learning and Survival

Under certain environmental conditions the ability to redirect or alter behavior, or to acquire entirely new patterns of behavior—in short, *instrumental learning* ability—is just as crucial for survival as are many unlearned behaviors. Observations of animal behavior in both natural and laboratory settings suggest many ways in which instrumental learning facilitates survival. For example, in the process of foraging, predatory species must decide which are the most likely places to look for food, how long to keep looking, how much risk to incur in the process of looking, and how to go about recovering food that has been stored previously (Kamil & Roitblat, 1985). Making, and especially *changing,* such decisions in the interest of maximizing fitness requires a good deal of behavioral modifiability as well as access to information learned from past experience.

Sometimes patterns of behavior that reveal great flexibility and ingenuity arise because of particular experiences individuals have had. One example of this kind of learning comes from the work of Jane Goodall, renowned for her detailed observations of the behavior of chimpanzees in their natural environment. One of the chimps Goodall describes, "Mike," learned to bang empty four-gallon kerosene cans together, presumably in an effort to augment his aggressive behavior toward other chimps. Goodall implies that such learning may have elevated his status within the chimpanzee troop (van Lawick-Goodall, 1971).

A more striking illustration of behavioral flexibility and ingenuity brought about in part through instrumental learning is the development, maintenance, and elaboration of human culture. Highly sophisticated brain mechanisms had to evolve in the hominid line in order to make possible the acquisition, retention, modification, and communication of information ranging from the skills required to shape effective tools to those involved in putting a man on the moon.

Clearly instrumental learning capacities are important contributors to survival and reproductive success in many species. They are particularly evident in the primates, especially humans.

Instrumental Learning and Biologically Prepared Responses

Most theories of instrumental learning formulated in the 1930s and '40s and refined (or forsaken) in the 1950s and '60s seemed to imply that all instances of learning could be explained in terms of the same basic mechanisms. In particular, it was assumed that any instrumental response made by any organism can be modified by applying the shaping, reinforcement, extinction, or punishment procedures discussed in this chapter. The species and age of the learner, the nature of the response, and the particular stimuli used to reinforce or punish the response were considered relatively unimportant in influencing the outcome of instrumental learning.

Consider the following statement by the learning theorist Clark Hull (1945): "The natural-science theory of behavior . . . assumes that all behavior of the individuals of a given species and that of all species of mammals, including man, occurs according to the same set of primary laws" (p. 56). Although Hull made allowance for the roles of innate species and individual differences, these qualifications tended to be ignored by most researchers. Also, some psychologists made assumptions about the relationship between stimuli and responses that were perhaps too simplistic. Consider the following interpretation of Skinner's operant theory: "In effect, in any operant situation, the stimulus, the response, and the reinforcement are completely arbitrary and interchangeable. No one of them bears any biological built-in fixed connection to the others" (Teitelbaum, 1966, p. 567).

Generalizations such as these seem extreme and highly questionable in view of more recent evidence. In some instances different species of mammals behave quite differently in artificial learning situations that are similar. Even within a given species, the nature of the response to be modified and the stimuli used as reinforcers are important considerations in determining the outcome of instrumental learning.

We turn now to a consideration of research findings that represent apparent exceptions to the rules of instrumental learning, or at least require an explanation that goes beyond those found in traditional learning theories. These seemingly anomalous learning phenomena appear to be adaptive for the species displaying them.

Autoshaping If psychologists wish to study the effects of various schedules of reinforcement on bar-pressing in laboratory rats, they first *shape* the rat to press a bar by reinforcing gradual approximations of that response. Shaping is necessary because a rat does not come into the lab with the bar press as part of its behavioral repertoire.

Similarly, shaping has been used to establish certain responses in other species for the purpose of exploring the effects of particular environmental variables on those responses. The most widely used experimental animals other than rats have been domestic pigeons, and the response of interest has been that of pecking at a lighted key or disc on the wall of a Skinner box. In shaping a pigeon to peck a key, gradual approximations of the response are reinforced with food. Normally a hungry pigeon can be shaped to key-peck within an hour or so if the techniques are applied carefully.

It was once thought that shaping was necessary for establishing key-pecking in pigeons, but we now know that this is not the case. Mere illumination of the key followed a few seconds later with access to food will get pigeons to peck at the key in about the same amount of time that it takes to shape the response (Brown & Jenkins, 1968). This phenomenon is called **autoshaping.** Interestingly, the pigeon does not have to make an approximation of a key-peck in order to obtain food; the food becomes available automatically along with illumination of the key, *regardless* of the pigeon's behavior. It appears that the pigeon learns to peck at the key without being reinforced for doing so. Moreover, the pigeon will learn to key-peck even if pecking results in *no* reinforcement—that is, when illumination of the key is followed with access to food, but pecking at the lighted key *prevents* access to food. Thus even under conditions that are counterproductive for getting reinforcers, pigeons still peck at the lighted key (Williams & Williams, 1969). Finally, if pigeons are both hungry and thirsty, their key-pecking in the autoshaping procedure varies *in form* depending on whether grain or water has followed illumination of the key. The key-pecks are vigorous and sharp with the beak slightly open when grain has been paired with the lighted key. When water is used, the key-pecks are slower and often accompanied by swallowing movements, and the beak is typically closed and in contact with the key longer (Jenkins & Moore, 1973). These response differences are similar to those we would observe if we saw pigeons actually eating grain or drinking water.

Autoshaping poses some interesting problems for traditional accounts of learning. In reward learning, responses get more accurate as a result of the consequences associated with the learner's responses—positive reinforcement. In autoshaping, however, reinforcement apparently is not responsible for increases in response accuracy; in fact, pigeons will autoshape even if pecking actually *prevents* them from gaining further access to food. Thus the law of effect does not seem to apply in the case of autoshaping. Why, then, *does* the pigeon learn to key-peck in the autoshaping experiment? To answer this question we must turn to principles of classical conditioning. The pecking response functions as if it were an unconditioned response to the food (the unconditioned stimulus). Because the lighted key is paired repeatedly with access to food, the lighted key becomes an effective (conditioned) stimulus for the pecking response. That is, the pigeon pecks at the lighted key because it has been associated with access to food in the past.

Prior to Brown and Jenkins's demonstration of autoshaping, the pecking response in pigeons had been characterized as an ideal example of an instrumental response that demonstrates all the laws of instrumental learning, just like bar-pressing in rats. But autoshaping seems better explained by principles of classical conditioning than by those of instrumental learning.

If we were to stop the discussion of autoshaping at this point, you might conclude that it is an interesting but puzzling instrumental learning phenomenon. You might feel cheated because we have not discussed *why* autoshaping works the way it does; we have told you only *how* it works.

To understand why autoshaping may work the way it does, it is useful to consider the functional significance of the response that is being modified. Pecking is an innate *food-getting* response. It seems reasonable to speculate that pigeons' survival often depends upon learning about the characteristics of food sources, and about the environmental stimuli that might signal the availability of food. In cases like this, natural selection may have favored learning mechanisms that do not require the painstaking construction of an appropriate response through reinforcement of approximations of that response. More generally, it stands to reason that learning is much more conducive to securing food and surviving if an animal need only direct its eating behavior toward stimuli that have been associated with access to food in the past. Instead of a lengthy shaping process, all that would be necessary is for the animal to have found food and noticed the characteristics of the environment associated temporally and spatially with the food.

"The Misbehavior of Organisms"

In 1951 two experimental psychologists, Keller and Marian Breland, reported enthusiastically that laboratory principles of instrumental learning could be used to control the behavior of a variety of species of animals under nonlaboratory conditions (Breland & Breland, 1951). Ten years later, in an article entitled "The Misbehavior of Organisms" (Breland & Breland, 1961), the authors were not so optimistic.

Using standard instrumental learning techniques such as shaping and appropriate schedules of reinforcement, the Brelands conditioned literally thousands of animals belonging to thirty-eight different species to perform "at various municipal zoos and museums of natural history . . . for department store displays, for fair and trade convention exhibits, for entertainment at tourist attractions, on television shows, and in the production of television commercials."

In the course of their work, the Brelands were struck by a number of behavioral oddities. For example, the Brelands encountered many difficulties in teaching a raccoon to pick up coins in its paws and deposit them in a metal box. Although the raccoon could be shaped to pick up a coin, it seemed reluctant to put the coin in the metal container. Instead, the raccoon would rub the coin against the inside of the container, pull it back out, and clutch it for several seconds before letting it go. When the raccoon was required to pick up two coins and deposit them in order to receive reinforcement, the interfering rubbing and clutching behavior intensified to such an extent that this particular project had to be abandoned. The raccoon appeared to get carried away with activities that resembled the unlearned "washing" of food, a behavior that is a natural characteristic of this species. This behavior persisted even though it prevented the hungry raccoon from receiving food.

In another instance, the Brelands attempted to teach pigs to pick up large wooden coins in their mouths and deposit them in a "piggy bank" located several feet away from the coins. Apparently this behavior was relatively easy to establish using standard reinforcement procedures. However, over a period of weeks or months the behavior became slower and slower. Instead of retrieving a coin and depositing it, the pigs would repeatedly drop it, root it along the way, toss it in the air, drop it again, root it some more, and so on. As with the raccoons, this interfering behavior, which resembled species-typical eating behavior, persisted and intensified even though the pigs were hungry and the behavior prevented them from obtaining food.

These are only two of several instances of "misbehavior" the Brelands describe to demonstrate an apparent reversion to unlearned behaviors:

> Here we have animals, after having been conditioned to a specific learned response, gradually drifting into behaviors that are entirely different from those which were conditioned. Moreover, it can easily be seen that these particular behaviors to which the animals drift are clear-cut examples of instinctive behaviors having to do with the natural food getting behaviors of the particular species. . . .
>
> These patterns to which the animals drift required greater physical output and therefore are a violation of the so-called "law of least effort." And most damaging of all, they stretch out the time required for reinforcement when nothing in the experimental setup required them to do so. . . .
>
> It seems obvious that these animals are trapped by strong instinctive behaviors, and clearly we have here a demonstration of the prepotency of such behavior patterns over those which have been conditioned.
>
> We have termed this phenomenon "instinctive drift" (Breland & Breland, 1961, pp. 683–684)

Clearly **instinctive drift** runs counter to traditional laws of instrumental learning. Instead of getting more accurate

Food washing, prior to eating, is part of the raccoon's instinctive behavior.

with repetition and food reinforcement, responses tend to change in the direction of species-typical unlearned behaviors associated with eating. Yet although the intrusion of these unlearned behaviors is not very adaptive in *artificial* learning situations, such as those imposed by the Brelands, in the animal's *normal* environment the triggering of appropriate food-getting and food-consuming behaviors by the presence of food has obvious adaptive benefits.

What the Brelands termed "misbehavior," like autoshaping, illustrates how principles of instrumental learning do not always work the way psychologists expect them to when biologically prepared responses are involved.

Other Examples There are many other instances in which the effectiveness of instrumental learning appears to depend on the kind of response selected for modification and on the kind of stimuli used as reinforcers. Golden hamsters learn to increase behaviors associated with food-getting (rearing up on hind legs, sniffing, locomotion) when they lead to *food* rewards. But other behaviors apparently not tied to hunger motivation (face washing, scent marking) do not increase in frequency when they are reinforced with food (Shettleworth, 1975).

The male of the sticklebacks, a small freshwater fish, will learn to swim through a wire hoop if such behavior is reinforced with the opportunity to display to a female that is ready to spawn. Male sticklebacks do not acquire this response if reinforcement consists of presentation of a male; males elicit aggression in other males. On the other hand, males will learn to bite a glass rod inserted into the fish tank if presentation of a male is the reinforcer, but not if presentation of a female is made contingent on this behavior (Sevenster, 1968).

Rats readily learn to run to another compartment of a "shuttle-box" or jump over a hurdle in order to avoid an electric shock (see Figure 8.6). They have a great deal of difficulty, however, learning to press a bar in order to avoid shock. Bar-pressing involves manipulative components that are observed more typically in eating than in defense situations. Likewise, pigeons apparently have no difficulty learning to fly from one perch to another to avoid shock, but it appears nearly impossible for them to key-peck to prevent the onset of a shock (Bolles, 1975).

What should we make of these apparent exceptions to the rules of instrumental learning? Basically this: the exceptions do *not* invalidate the learning principles discussed earlier in the chapter. Many of the principles do have considerable general validity, particularly for organisms characterized by a great deal of behavioral flexibility, such as the primates. However, the exceptions extend and enrich our knowledge of learning. Many of the variations in learning seem more understandable in light of the ecological demands that confront an organism in its natural environment. From an evolutionary perspective it makes sense that some response-reinforcer relationships are acquired more easily than others by a given species, and that different species may be programmed through natural selection to acquire biologically useful information in different ways.

Observational Learning

Acquiring patterns of behavior from witnessing these patterns in others is called *observational* or *imitative learning.* Observational learning can be considered a type of instrumental learning. However, there are certain features that place observational learning in a class by itself. Observational learning can take place without trial-and-error procedures and without the presence of any apparent external reinforcers. It also can occur with long delays between observing the actions of others and performing them. The major ingredient in this kind of learning is the presence of other individuals, and for this reason observational learning is sometimes referred to as *social learning.*

Although some psychologists have implied that observational learning is a particularly human phenomenon (Liebert, Poulos, & Strauss, 1974), this kind of learning can be seen in a variety of species. Some species of birds acquire their species-typical songs, or parts of them, through hearing the songs of their fathers. Members of a troop of Japanese macaques (a type of monkey) reportedly learned to wash some of their food before eating through observing other members of the troop doing so (Hinde, 1974). Young patas monkeys learn to avoid a particular box if they observe their mothers responding fearfully on opening it (Dewsbury, 1978). Finally, chimpanzees and gorillas appear capable of learning many of the signs of American Sign Language through observation and imitation.

Of course, observational learning is most easily seen in humans. Babies begin to mimic their parents or other models early in life. As children grow older they become quite interested in and adept at imitating adults, especially their parents. It is not uncommon, for example, to see a three-year-old boy going through the motions of driving a car as he watches his father seated next to him actually doing so. Nor is it unusual to see children of this age pretending to shave, playing dress-up, or ministering to their dolls in an attempt to imitate some of the behaviors characteristic of their parents. School-age children often imitate older brothers or sisters, highly popular peers, and even heroes or villains they see on television or in the movies. Adolescents and young adults may pattern some of their attitudes and behaviors on those of prestigious "role models," such as a successful athlete, a fashion model, or a respected teacher. In short, the inclination to imitate and learn through observation is deeply ingrained in our species.

Primates appear highly specialized for observational learning, as exemplified by the gorilla Koko, shown here with trainer-researcher Penny Patterson. Koko has learned hundreds of signs in American Sign Language through observation.

Sometimes a distinction is made between observational learning and social facilitation. According to this view, observational learning involves acquisition of a *new* behavioral pattern, or one the learner is unlikely to produce spontaneously. Of course, the learner must have the necessary skills for producing the pattern. By contrast, **social facilitation** involves production of a pattern that is already an established part of the observer's behavioral repertoire. That is, seeing another individual engage in a familiar behavior can facilitate that behavior in the observer. For example, rats are more likely to engage in eating or copulatory behavior if they observe other rats performing either of these activities (Dewsbury, 1978). Nursery school teachers sometimes see some of their children engage in aggression or mock aggression just after having observed an aggressive encounter among other children. The aggressive behaviors of the observing children are not new to them. Rather, observing seems to facilitate behaviors these children had exhibited on other occasions.

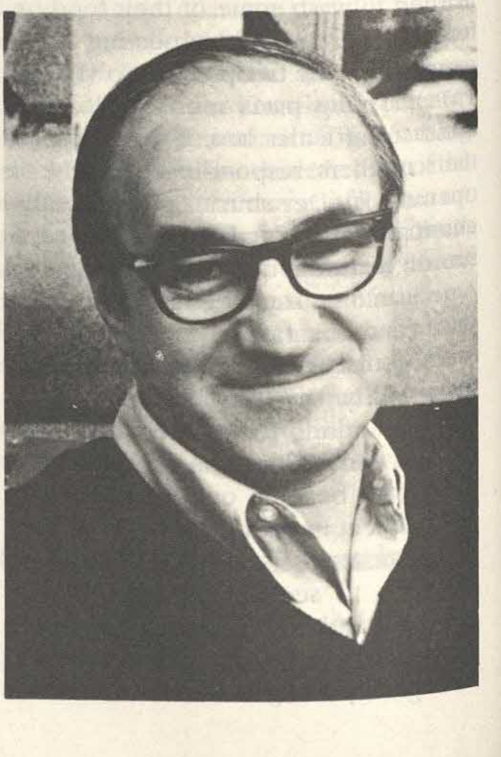
It is also possible for previously established behavior to be *inhibited* through observation. For example, a thirteen-year-old girl, ready to give her mother what for for not letting her stay out late during the week, suddenly bites her tongue after seeing her older brother punished for talking disrespectfully to Mother.

The foregoing has distinguished between the learning of relatively *novel* patterns of behavior and the performance or inhibition of *well-established* patterns due to observation of the actions of others. However, in view of our broad characterization of learning as the acquisition and retention of information, we see no reason to infer learning only in situations involving the acquisition of new behavioral patterns. Learning also involves getting to know when to do something you already know how to do, and when to refrain from doing it. In fact, this is the essence of discrimination learning.

If the observer acquires discriminative information from viewing the acts of another, and perhaps the consequences of those acts, we would classify this acquisition as observational learning, even though the learner already knew how to perform the acts being modeled. For example, a young boy comes to discriminate between those occasions on the playground or in the classroom when hitting another child will pay off (nothing bad happens to the hitter) and when it won't (the hitter gets punished) through observing the actions of others in various circumstances. In this case, the boy does not learn a new response, but learns when to engage in aggressive actions and when not to.

Much of what we know about observational learning is based upon the research and theoretical notions of psychologist Albert Bandura (Bandura, 1973, 1977; Crain, 1980). For nearly

Albert Bandura is recognized for his research and theory on observational learning, particularly children's imitation of televised aggression.



twenty years Bandura has advocated the need to understand observational learning because he believes it to be a major force in shaping behavior, especially the behavior of children. Bandura and his colleagues have been responsible for stimulating a great deal of research, much of it controversial, exploring the effects of TV violence on aggression in children. These studies have not been limited to aggression, however, for they have demonstrated that the acquisition of a variety of behaviors and attitudes may depend at least in part on observational learning. We now turn to a brief consideration of those factors that can facilitate or interfere with observational learning, and of Bandura's account of the processes underlying observational learning.

Establishing and Maintaining the Response

What are the necessary conditions for observational learning? There is only one: observing the model perform the behavior. It is not necessary for the model to be reinforced, or for the observer to be reinforced for imitating. It is not even necessary for the observer to observe a "live" model. Models on TV or in books appear to be equally effective in establishing observational learning.

Although reinforcement is not necessary for observational learning, it can facilitate such learning in certain circumstances. For example, some studies have shown that individuals are more likely to imitate a behavior they have observed if the model is given a reward contingent on engaging in that behavior. A five-year-old boy may witness an eleven-year-old using unsavory language and receiving a great deal of attention from his peers for doing so. Subsequently, the younger child may experiment with profanity in the presence of his own peers, presumably because he expects it will pay off in increased popularity as it did for the model. Bandura has called this phenomenon **vicarious reinforcement** because the observer is not reinforced directly. It is as though the observer imagines what it would be like to receive the same rewards as the model, and this becomes a compelling reason for imitating the model.

It is interesting to note that in the case of overt aggression, reinforcing the model's aggressive acts is *not* necessary for observational learning, nor does it improve the efficiency of such learning. For example, in one experiment Bandura found that models who were aggressive were imitated readily whether they received rewards for their aggression or received nothing. This suggests that it is important to consider the *nature of the response* in formulating principles of observational learning, or any kind of learning, for that matter.

Bandura has proposed four component processes that govern observational learning: *attention, retention, motor reproduction,* and *reinforcement and motivation.*

Attention In order to acquire any kind of information we must attend to it first. This is as true in observational learning as it is in classical conditioning and instrumental learning. Anything that increases the likelihood that an individual will attend to what a model is doing will also raise the chances for observational learning. If a model is distinctive in appearance or actions, prestigious, powerful, or promises in some way to fulfill the needs of the observer, that model is more likely to be imitated by the observer.

Retention Our definition of learning includes the notion of retention of information. It is obvious that varying degrees of retention are necessary for observational learning. Sometimes very long-term retention is required, because the learner does not imitate the model for a long time after observing the model's behavior. This seems to be the case, for example, when parents begin to use particular methods of discipline with their young children. The disciplinary techniques chosen often are those which the parents observed *their* parents using, and perhaps swore they would never adopt with their own children. We also see evidence of deferred observational learning in nonhuman species. The white-crowned sparrow acquires parts of its species-typical song through exposure to the song of its parents—through observational learning. However, the young sparrow must hear the song between ten and fifty days after hatching. Moreover, even if the bird never hears the song after this time, it will begin singing the *complete* white-crown song at about five months of age.

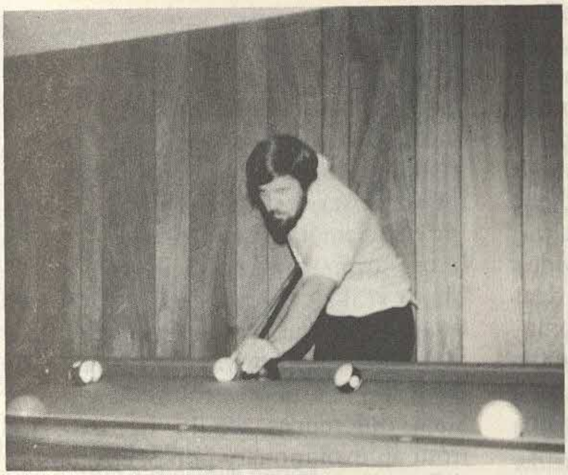
Motor Reproduction In order to imitate a new behavior accurately, the observer must have the requisite motor skills and coordination. For example, a seven-year-old girl may see how to operate a car with a manual transmission by observing her father doing so, but the child probably will not be able to translate this information into appropriate actions because she has not yet developed the necessary motor coordination to shift the gears and operate the clutch simultaneously.

Reinforcement and Motivation Reinforcement and motivation can be particularly important in influencing observational learning. A young boy may learn to curse from observing older children doing so. However, the boy may be more likely to display his new knowledge if he sees the older children praised for cursing (vicarious reinforcement), or if he is frustrated by the actions of another (motivation). On the other hand, the boy may not curse if he sees that some of the older children are punished for cursing (vicarious punishment), or if he himself is threatened with punishment (motivation).

We need to make one qualification concerning punishment and observational learning. Bandura found that children who witness a model being punished for aggression are less likely to imitate the aggressive act than are children who observe the model rewarded. However, children in the model-punished condition can be induced to perform the modeled act through the promise of rewards, and they perform it just as accurately as do the children in the model-rewarded group. In other words, punishment of the model seems to inhibit performance of the modeled act by the observer, but it does not cause the observer to forget how to perform the act.

The Development of Observational Learning

The classic account of the development of imitative ability has been given by Piaget (1962). During the first few months of infancy imitation is restricted to acts the child has performed before, and up to about eight months of age infants can imitate only those acts they can see themselves make. By the end of the first year, infants can imitate actions they cannot see themselves perform, such as var-



This may be an instance of motor reproduction, one aspect of observational learning.

ious facial gestures, and they can imitate novel actions, behaviors they have never before performed. By the end of the second year, children have become quite accurate in copying others, and they can imitate on a deferred basis. That is, they may witness a model's actions, show no immediate attempt to imitate, but surprise everyone by performing the action flawlessly hours or days later.

There is a good deal of evidence to suggest that the ability to imitate others becomes refined gradually during the first two years of life (Piaget, 1962; McCall, Parke, & Kavanaugh, 1977). There is much debate, however, over when during infancy imitative ability is first manifested and how early children are able to imitate on a deferred basis. Meltzoff and Moore (1977) reported evidence of imitation in infants during the first few days of life. Most remarkably, their work shows that these young infants can imitate actions they cannot see themselves make, such as tongue protrusions and mouth openings, and that they may be able to defer their imitations over a period of seconds or minutes. Although these findings have met with controversy (Jacobson, 1979), they have been replicated by other workers (Field, Woodson, Greenberg, & Cohen, 1982). If what these investigators have found is genuine imitation, then this suggests a much earlier emergence of observational learning ability and primitive mental representation than many psychologists would have believed possible. But considering the highly social nature of our species and the vast amount of information to be acquired during childhood, it would certainly be advantageous to have imitative ability at or shortly after birth.

The Adaptive Significance of Observational Learning

Observational Learning and Survival

The ability to learn through observing others undoubtedly plays an important role in the survival of many species, although its importance varies for different species, as we shall see shortly. Imitative learning can provide a quick and effective means of acquiring biologically significant information, ranging from the location of food resources, suitable nesting areas, and predators, to systems of communication and language. The value of being able to alter behavior without much trial and error, and without the need for reinforcement, seems obvious for species that must acquire a great deal of information during their lives, sometimes quickly. This is especially true for many mammalian species, particularly the primates, which rely heavily on learning for survival.

In humans, observational learning probably is crucial to the process of socialization. Socialized individuals are, by definition, adjusted to the group — the family, society, culture — in which they have been raised. It seems quite reasonable to assume that individuals who fail to become socialized have difficulty in adjusting to their environments, and they may well be at a disadvantage when it comes to survival and the production of offspring who will in turn survive and reproduce. In the past, before the advent of humanitarian treatment of the mentally ill and of criminals, unsocialized children and adults met with harsh measures, often resulting in expulsion from the social group, death, or both. Even today, those who are unable to conform or who break the rules of society (and get caught) may be institutionalized, incarcerated, or killed. Obviously some of these consequences are not conducive to survival and reproduction, and others often make unsocialized individuals poor risks as marriage partners and parents. Thus if being socialized is an adaptive characteristic, then anything that contributes to this end, including observational learning ability, would also be adaptive.

Species Variations in Observational Learning

Given the discussion of species differences in learning earlier in this chapter, it should come as no surprise that the role of observational learning in achieving behavioral change can be quite different from one species to another. There is now a good deal of evidence suggesting that related species may differ in important ways in terms of the *what* and *how* of observational learning. Such differences would be expected from an evolutionary perspective, since different species have experienced different adaptive demands during their histories.

Song Learning in Birds Song learning in birds is an illustration of how reliance upon observational learning can vary strikingly among different species. It is possible to find instances where no evidence exists that learning plays a role and instances where learning seems to play a crucial role in song acquisition.

Bird songs can be distinguished from bird calls. Bird calls are relatively simple, require little if any learning, and are produced by both sexes of most species. Calls are associated with such things as distress and begging and some other motivational or emotional conditions.

Songs are more complex and variable than calls, often extremely complex, and they are produced by males of many species. Males of a large number of bird species use their songs to announce their claim to a breeding territory and their willingness to defend that area against competitors. To an unmated male an unmated female of the same species is not a competitor, and the male's song announces to females that he is a territory

The white-crowned sparrow appears to be biologically predisposed to learn its species song during a sensitive period.

holder and therefore a suitable mate. Females tend to pick the best available territory that is held by an unmated male and accept him as a mate. Females only respond to the song of the species to which they belong, so if a male is to pass his genes to the next generation, it is of utmost importance that he sing the proper species-typical song.

1. No evidence for learning. The songs of various species of doves do not need to be learned. Doves reared with a foster species and isolated from the songs of their own species still acquire the song typical of their species. Interestingly, it has also been shown that dove hybrids develop songs that contain the distinctive elements of *both* of their parent species' songs (Lade & Thorpe, 1964).

Certain species of brood parasites—birds, such as the European cuckoo and the brown-headed cowbird, that deposit their eggs in the nests of other species—also do not depend on learning for their song development. The young of these species, even though exposed only to the distinctively different song patterns of their foster parents, nevertheless produce their own species-typical song.

2. Evidence for learning. Many other species of birds rely entirely on learning for the development of their song. Male bullfinches and zebra finches raised under normal conditions learn the song of their fathers and therefore sing the species-typical song. However, if they are raised by adults of certain other species they will learn the song of their foster fathers, even though males of their own species are singing nearby. Bullfinches can even learn to mimic human whistles. Thus these species appear to be completely open to learning the song that their fathers sing, whatever it may be; the same is true of many other species.

The situation with other birds is much more complex. White-crowned sparrows have been studied extensively, and results indicate that, under normal conditions, male white-crowns (1) learn only a proper white-crown song and not the song of any other species; and (2) to sing only certain elements of the white-crown song if they have never heard it sung. In other words, if they hear a white-crown song they will learn it; if they do not hear a white-crown song they will sing parts of it, but the production will not be recognizable as the song of a white-crown.

> Song learning by white-crowned sparrows illustrates what should be familiar principles by now. This species is predisposed to learn a specific kind of information. Its learning mechanism is highly selective in what it can acquire and is very sensitive to the "right" information. In addition, there are definite constraints on what this animal can learn. It can learn to sing only white-crowned sparrow songs. It can store the necessary information only during a limited period early in its life. It can utilize the stored information only if auditory feedback is present so that the

> young male can match the sounds it produces with the remembered sounds it learned in the past. Song learning by this sparrow is the product of special abilities coupled with special restrictions (Alcock, 1979, p. 73).

A further complication in many bird species, including white-crowned sparrows, is the existence of dialects — slight but recognizable differences in the species-typical song in different areas, sometimes only a few miles apart (Konishi, 1978). Because the young male learns his song as a nestling, he learns the local dialect. Different individuals display slight variations even within a dialect, a factor that may have led to the development of dialects in the first place.

As mentioned earlier, the adaptive value of bird songs appears to be that they function as territorial defense and "advertisement." But why do we see such diversity in the development of bird songs, with some species relying completely on learning, some completely on innate (nonlearning) mechanisms, and some on both? At present the answer to this question is far from clear. There are simply too many unresolved complexities associated with bird songs, and too little is known about differences in selection pressures on the various species of songbirds. There is, perhaps, an easier question to deal with: Why have some species of songbirds evolved a vocal learning mechanism at all? What possible selective advantage would the ability to *learn* elements of the species-typical song have over the ability to simply *sing* the song without having to learn it?

Two speculative explanations have been offered, one by Nottebohm (1972) and the other by J. Brown (1975). The basic assumption underlying both accounts is that highly complex songs can be transmitted from generation to generation more reliably through learning than through direct genetic programming. Nottebohm argues that the more complex the song, the more attractive it is to the females of certain species of songbirds. Thus, song learning ability could have evolved because males who could copy or generate the most complex songs through observational learning were selected over those who did not have this ability.

Brown summarizes an alternative explanation:

> The principal objection to Nottebohm's hypothesis is that there is a negative correlation between song complexity and mating systems that favor sexual selection.* Most of the best singers and versatile vocal learners . . . are monogamous. Promiscuous and polygamous species tend to have simple songs, whereas according to Nottebohm's theory they should have the most complex songs and should show more vocal learning ability.
>
> If [bird] songs . . . are considered as adaptations for improving the efficiency of territorial advertisement, perhaps their principal function would be in repelling males rather than attracting females. If, as seems likely, females of monogamous species choose males more on the basis of the qualities of their territories than the qualities of the males, the role of song in defense against males would seem to be more important than its role in attracting females. Then, if the more complex, culturally transmitted songs are the most effective, vocal copying will be selected (1975, p. 674).

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* **Sexual selection** is a type of natural (or artificial) selection in which one individual is more likely to reproduce than another because of competitive mating. In other words, the successful individual is selected by an individual of the opposite sex to mate with; the unsuccessful one is not.

Developmental Constraints on Observational Learning

For some kinds of behaviors, and for some species, observational learning occurs most readily during a particular developmental period. Two widely studied instances of developmental constraints on observational learning are song learning in birds and human language learning.

Song Learning Revisited. There appear to be sensitive periods for acquiring the species-typical song in species in which learning plays a role. For example, the optimal age for song learning in white-crowned sparrows is said to be somewhere between ten and fifty days (Marler & Mundinger, 1971; Marler & Tamura, 1964).

However, much of the evidence suggesting a well-demarcated sensitive period for white-crowns comes from studies in which birds were exposed only to audio *tape-recordings* of adult songs. More recent experiments have used live social "tutors" to model songs for birds of various ages. In one of these experiments white-crowns fifty days of age were exposed to tutors of a *different* species who, of course, sang a "foreign" song. Interestingly, all twelve of the white-crowns so exposed learned the foreign song, even though they were beyond the optimal age for song learning (Baptista & Petrinovich, 1984). These findings suggest that sensitive periods based on hearing a tape of the adult song may differ from those based on observing the adult sing the song. They also question the widely held belief that white-crowns cannot learn the songs of an alien species.

Human Language Learning Human language is an extremely complex yet flexible communication system involving *symbols* that are organized according to *rules.* The rules specify how sounds are combined to form words, how words are combined to form sentences, and how meaning changes depending on the sounds, words, and word combinations that are used.

Normally we learn most of the rules and strategies for comprehending and producing spoken language within the first four years of life. Considering the complexity of language, this is an amazing accomplishment. Imagine: children are not formally taught the rules for deriving meaning from the sounds they hear, or for combining sounds and words to express themselves, yet they learn to talk nonetheless. Thus children must extract the rules of language on their own. This is a complex and very *active* kind of learning. Children not only imitate the speech they hear, but observe and learn how the elements of speech are put together to convey meaning. However, although their use of speech is rule-governed, children would be hard pressed to identify those rules.

The acquisition of the complexities of human language is so rapid, so similar across even highly diverse cultures, and tied so closely to motor development that some linguists and psychologists believe there is a strong genetic basis for this kind of learning. Consistent with this hypothesis, the late Eric Lenneberg (1967, 1969) reported evidence for the existence of a *sensitive period* associated with the acquisition of one's native language. Lenneberg hypothesized that the preschool years represent the *optimal* time for learning language under normal circumstances. The time period during which language *can* be acquired, however, is much longer in duration. It is supposed to range from approximately two years until the early teens. If children are not exposed to language prior to adolescence, the chances are very low that they will ever make much progress toward understanding or producing it appropriately thereafter.

Why should the kinds of observational learning discussed so far occur relatively early in life, and only during a fairly restricted time period? Certainly the fact that birds learn to sing and humans learn to speak before reaching sexual and physical maturity seems quite adaptive. Song learning influences territorial defense and "advertising" and, ultimately, the procuring of a mate. So it seems important that song learning be complete by sexual maturity. In the case of early language learning any speculation must rest on much shakier ground. It is possible that in the past early speakers were better cared for by parents — surely they could better make their needs known — and were therefore better equipped for effective communication and cooperation in hunting and gathering at an early age. Thus early language acquisition may have favored improved technical skills as well as communicative skills, and might have led to a higher probability of securing a mate, or of securing a mate earlier, and thus the production of more offspring and better provision for their success. It is also possible, of course, that early language was a by-product of other kinds of early development — particular kinds of cognitive attainments and increasing neuromuscular coordination — required for survival.

But wouldn't *prolonged* flexibility to learn be preferable to a relatively *restricted* time period? Although it may seem like it, this may be a case of not being able to have your adaptive cake and eat it too. Consider song learning as an example. It may be that the nervous system can support a tendency to learn the characteristics of the species-typical song only for a limited amount of time. Perhaps this is because the nervous system, in following a genetically programmed timetable, eventually must change so as to support the development of other adaptive activities. It is also possible that continually hearing the parent's song (and perhaps singing it) allows the bird to make necessary discriminations (for example, learning to recognize the characteristics of its species-typical song or population dialect), thus reducing the motivation to learn just any song. Perhaps the learning that has taken place actually changes the bird's inclination for further learning of this kind, effectively ending the sensitive period. Similar factors may be responsible for terminating sensitive periods related to other learning phenomena.

Supplement 1 Imprinting: A Unique Kind of Adaptive Learning

For mammals and many birds, one of the most important requisites for the survival of young and the development of appropriate sexual behavior is the capacity for forming and maintaining social bonds. **Imprinting** is a form of learning that can play an important role in establishing such bonds. It has been widely documented in various species of birds, particularly those which are *precocial,* that is, able to locomote and feed shortly after hatching. To be specific, imprinting is the *process*

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Konrad Lorenz, an ethologist, is famous for his studies of imprinting, a form of learning involved in the formation of a bond between offspring and parent in many animal species. Here, Lorenz himself appears to be the object of imprinting.

of forming a social attachment, usually to the parent, as a result of *experience* during a *sensitive period* of development.

It was the famous ethologist Konrad Lorenz who first scientifically documented the imprinting phenomenon (1937). Lorenz observed that goslings, domestic chicks, ducklings, and certain other birds typically followed the first moving stimulus they encountered after hatching and leaving the nest. Normally the first moving stimulus would be the bird's mother. But Lorenz noticed that stimuli other than the mother could elicit the following response. Animals of a different species, various inanimate objects, and even Lorenz himself were all effective stimuli. Lorenz had much to say about imprinting, but his basic points are summarized nicely by Mitchell (1973):

> The key features of imprinting appeared to be 1) that it had to occur during a very brief sensitive period in the bird's life as a result of following a moving object. Failure to accompany the moving object during this period of time meant that social attachment would not be acquired at all. 2) However, once imprinting had taken place it had effects on the bird's behavior as an adult. 3) The stability of these effects was most dramatically expressed in the sexual behavior of imprinted birds. For example, male mallard ducklings which had followed a male instead of a female mallard shortly after hatching, would as adults court males but not females. Similarly, as a result of being the first moving object in the lives of a substantial number of greylag geese, Lorenz himself had been courted by a good many male greylags; these geese readily chose him (or any other available human being) in preference to female greylags. Thus during imprinting young birds normally learn to recognize females — information which they will not employ in sexual behavior for many, many months but which is absolutely critical for normal reproductive behavior (pp. 104–105).

Lorenz's observations and interpretations of imprinting stimulated a great deal of research activity. Most of the subsequent investigations of imprinting have been carried out in the laboratory with domestic chicks and ducklings, and have looked only at the behavior of young animals. The phenomenon studied in such investigations is called *filial* imprinting, because the focus is on the establishment of preferences for the parent or substitute parent — the imprinting stimulus — during the sensitive period. The few studies that have attempted to relate animals' sexual preferences and objects of courtship to imprinting are studies of *sexual* imprinting.

Most studies of filial imprinting reveal little evidence of *unlearned* preferences for the natural parent, and highlight the importance of early learning in establishing social bonds. The work on sexual imprinting also underscores the importance of early learning in influencing the choice of a mate, but the particular role played by learning appears to vary with different species.

Clearly there is an important learning mechanism in both filial and sexual imprinting, but they also appear to have unlearned components. The following response among some birds appears to be unlearned, but the resulting attachment to the stimulus appears to fit our definition of learning quite well: It is important to note, however, that psychologists and biologists have never been quite sure how to characterize this kind of learning. It does not appear to be a straightforward example of either classical conditioning or instrumental learning, although some researchers continue to try to fit imprinting into one or the other of these models (see Hoffman, 1978, for a classical conditioning interpretation). Moreover, unlike many other examples of learning, imprinting is restricted to a particular developmental time period in the animal's life, the sensitive period, and it can take place after as little as a few minutes' exposure to the imprinting stimulus.

In addition, it is extremely difficult to interfere with imprinting once the animal is following the imprinting stimulus. As we saw earlier in the chapter, responses to a stimulus that are punished are less likely to occur in the future, particularly if the punishing event is immediate and intense. But this rule does not appear to hold in imprinting. Punishment actually *improves* the effectiveness of imprinting.

These exceptions to the rules appear to be extremely adaptive. Under natural conditions, it would be important for young **precocial** animals — those that can locomote immediately after hatching or birth — to become attached to their parents early and quickly, in order to ensure survival. Moreover, these animals are likely to encounter obstacles and punishing events while attempting to follow their parents, such as falling into holes in the ground. Surely it would not be conducive to the animals' survival if such experiences weakened or inhibited the following response, and imprinting itself. Thus it would not be surprising if natural selection favored a mechanism that served to *increase* following and attachment in the young in response to aversive stimulation. It is interesting to note in this regard that young children who have histories of being abused by their parents often show surprisingly strong attachments to their parents.

Let us turn now to a consideration of the extent to which different species of birds rely on imprinting for development of social attachments. One of the most inter-

Male and female doves show little variation in physical appearance, while male and female mallards have strikingly different coloration. These species differences may be related to observed variation in patterns of imprinting for the two species.

esting examples of species differences involves a comparison of sexual imprinting in mallard ducks with that in various species of doves.

It seems quite clear that doves are extremely imprintable. Over sixty years ago Whitman (1919) noted that the only way he could get doves of two different species to mate and produce offspring was to rear the young of one species in the nest of another. This is called *fostering.* When the fostered doves reached sexual maturity, they preferred to mate with the foster species.

More recent experimental studies have documented sexual imprinting in several species of doves. In one example, eggs belonging to three species of doves were cross-fostered by exchanging eggs between nests; thirty of thirty-seven male offspring and nineteen of twenty-eight female offspring oriented their sexual behavior only toward members of their fostering species, while four males courted various species indiscriminately and inconsistently, and the remaining three males and nine females showed no sexual behavior. In no case did the fostered individuals prefer members of their own species. On the other hand, a control group of doves raised by their own species courted only members of their own species (Brosset, 1971, cited in Brown, 1975).

These data suggest that early learning plays a crucial role in determining the object of courtship for doves. In addition, we have already seen that studies of filial imprinting indicate that early learning can play an important role in determining the object of the following response. Considering all this, it might be tempting to conclude that early learning may be necessary for the development of social bonds in all species of birds, and perhaps in other classes of animals as well. But such generalizations would ignore predictions based on the theory of evolution suggesting the possibility of adaptive *variation* in behavioral mechanisms, even among closely related species. Most important, these generalizations do not appear to be warranted in view of observations of sexual imprinting in other species.

Consider sexual imprinting in mallards. Compared to doves, it appears that there is much more variability, and therefore less predictability, in imprinting in mallards. For example, in one study none of the sexually mature control animals of both sexes who had been raised with mother and siblings of their own species even attempted to court members of other species. But experimental mallards raised by foster species showed mixed courting preferences. Sixty-five percent of the experimental males courted females of their foster species, indicating a preference for the imprinted species, but this was far from universal; over a third of them preferred females of their own species. Experimental females, on the other hand, showed much lower imprintability to a foster species. Only 17 percent of the experimental females courted males of their foster species, while 83 percent preferred males of their own species. In addition to these observations, it was reported that mallards of both sexes raised in visual and auditory isolation from other ducks for nine weeks nonetheless mated normally with members of their own species (Schutz, 1965, cited in Brown, 1975).

The evidence we have reviewed suggests that mallards, in contrast to doves, may have an unlearned preference for mating with their own species, one that can be altered sometimes by imprinting, at least in males.

But what accounts for these species and sex differences in imprintability? One reason why doves do not show evidence of unlearned species recognition may be that they are **altricial,** not precocial. Altricial birds are helpless at hatching and remain in the nest for some time. As a result they have more time to learn about characteristics of their parents that will later aid them in recognizing their own species. This does not mean that all altricial species should rely more on learning than precocial species do; factors other than helplessness at hatching undoubtedly contributed to variations in degree of sexual imprintability among different species.

A reason why mallards show more variability in sexual imprinting than doves do may have to do with sex differences in coloration. Mallards are sexually **dimorphic;** males and females appear strikingly different in plumage color, the males being the most colorful. On the other hand, the doves tested are sexually **monomorphic;** the sex differences in plumage are not very apparent.

In ducks, the males of different species differ markedly from one another in coloration in most cases, but females of different species are often quite similar to one another. While females may use the distinctive color cues of males to identify males of their own species, males need a different means for recognizing females. Therefore natural selection would favor an imprinting mechanism in male mallards. There would be no selective advantage for an imprinting mechanism in females because it would not be necessary for species recognition. This assumes that it is more "economical" for genes to specify unlearned capacities than learning mechanisms, since the neural circuitry involved in learning is probably more complex in most instances. In addition, in most species of ducks the young are reared by the female, so there is no opportunity for immature females to learn about the characteristic appearance of the adult male.

This interpretation, although logical and consistent with the evidence, is speculative. Much more research on sexual imprinting will be needed before we can determine all the factors that are important in accounting for species differences in imprinting.

The Physiology and Motivation of Behavior

Chapter 9 The Physiological Bases of Behavior

Chapter 10 Motivation, Emotion, and Behavior

UNIT IV

The Physiological Bases of Behavior

The attempt to understand the relationship between mind and body has engaged some of the world's greatest philosophers. The early Greeks differed in their views of the mind-body relationship. Plato opted for a distinct separation between the two — mind-body dualism. On the other hand, Democritus argued that mind and body were made of the same basic "stuff," which he called atoms, and that the same set of fundamental principles could explain both mental and physical phenomena. Much later, during the Renaissance, Descartes speculated that although mind and body were separate entities, they interacted in the brain.

Although the mind-body problem may never be resolved to everyone's (or perhaps anyone's) satisfaction, it is now clear that the two are intricately related. Physical events in the body, especially in the nervous and endocrine systems, influence thoughts, motivations, and feelings. Scientists have identified different centers in the brain which control various cognitive, motivational, and emotional processes. For example, the brain contains highly specialized centers for understanding and producing speech, for controlling sleep and waking, for regulating hunger and thirst, and for producing feelings of pleasure and pain. The mind also influences the body. For example, perceiving life-threatening danger in a situation activates a part of the nervous system that prepares us to fight or to flee from the situation. Dwelling on psychologically stressful events for a prolonged period of time may cause changes in the amounts and kinds of hormones produced by the body.

Biological motives, such as those associated with securing food and water and with sexual reproduction, are tied directly to known functions of the nervous and endocrine systems. Unless we experienced such motives we would not do the things that are necessary to survive and to continue our species. Much less is known about how our physiology influences other motives, such as those arising from the need to affiliate with others or to achieve mastery over the environment. Nevertheless, such motives appear to share the same basic function as the biological motives; they cause us to adopt strategies for coping successfully with the challenges posed by the environment.

9

The Physiological Bases of Behavior

The Evolution of Nervous Systems

Structural and Functional Aspects of the Human Nervous System

The Brain and Behavior

Right Brain–Left Brain

The Endocrine System

Supplement 1 Development of the Human Nervous System

Supplement 2 The Functioning of the Endocrine System

Supplement 3 Endorphins: Animal Opiates

Chapter Preview

All behavior has a physical basis. Behaviors, along with internal adjustments and processes, allow animals to respond to and cope with conditions in the external environment. Single-celled organisms and plants are successful without nervous systems. All animals above the evolutionary level of sponges possess a nervous system, and the complexity generally increases the more advanced and more complicated the animal. However, the basic function and importance of nervous systems are the same for all animals—to sense information about the environment, the animal, and the relations between the two that are significant for survival and success, and to make physiological and behavioral adjustments based on this information.

Sensory systems are parts of nervous systems. The central nervous system (CNS) includes the brain and spinal cord, which are mainly involved in integrating information from the senses and the peripheral nervous system. All nervous structures outside the CNS are included in the peripheral nervous system, which is subdivided into the *somatic* nervous system and the *visceral* nervous system. The somatic nervous system transmits information from sense organs and controls skeletal muscles. The visceral nervous system serves the internal organs, such as the heart, the digestive system, and various glands.

Neurons are the basic structural units of the nervous system. A neuron is a cell that is specialized to transmit information in the form of electrochemical impulses. In general, neurons transmit information to and from, and within, the CNS.

A neuron that responds to stimulation by passing stimuli to other neurons is said to be *excited*. But neurons also can be inhibited from passing impulses. Inhibition aids in the normal functioning of the brain and muscles.

The brainstem connects with the spinal cord, and includes the medulla, pons, midbrain, and reticular formation. The medulla is involved in feeding, digestion, breathing, and heart control. The pons is a major control center for facial expression, feeding, hearing, and balance. The midbrain controls eye activity and is involved in visual perception. The reticular formation is in the core of the brainstem; it integrates a variety of information, and is involved in swallowing, vomiting, respiration, cardiovascular functions, and sleeping and waking. The cerebellum, a structure near but not included in the brainstem, controls equilibrium, posture, and coordination.

The forebrain is attached to the brainstem, and includes the diencephalon and telencephalon. The diencephalon includes the hypothalamus, which is involved in hormone secretion, emotional behavior, and monitors several aspects of the internal environment; the thalamus, which receives and relays sensory information regarding taste, touch, vision, hearing, and pain; and the epithalamus, which includes the pineal body that is associated with detection of day length.

The telencephalon includes the limbic system and the cerebrum. The limbic system is a group of structures involved in smell, emotion, motivation, arousal, and memory. The cerebrum is divided into left and right hemispheres, and covers most of the rest of the brain. The cerebral cortex is the thin outer covering of the cerebrum, and includes sensory, association, and motor control areas.

The right and left halves of the human brain are responsible for certain different functions. However, connections between the two halves normally provide for the integration of these activities.

The endocrine system consists of several glands in different parts of the body that control and integrate body functions by releasing hormones into the bloodstream. Most of these glands have no structural connections with each other, nor with the organs they affect.

In Supplement 1 we discuss the structure and function of the nervous system from a developmental point of view. Some of the various structures that develop at different times in the growing embryo and fetus are described, along with their functions. Supplement 2 discusses functioning of the endocrine system and

examines sex hormones and growth hormones in some detail. Endorphins and enkephalens, opiates secreted by the body in time of stress, are the topic of Supplement 3.

There is no instance of behavior, however simple or complex, that does not have a physical basis. This does not mean that behavior is nothing more than organized patterns of nerve cells firing, muscles contracting and relaxing, or glands secreting hormones. But it is clear that such events can be causes or consequences of behaving.

There has been a virtual explosion of information derived from investigating the relationship of physiology to behavior in recent years. An astounding number of facts are known about the neural correlates of behavior that were mere speculations just two decades ago (Farley & Alkon, 1985). During the past ten to fifteen years great advances have been made in our knowledge of the mechanics of neural transmission and its role in influencing behavior, hormonal effects on behavior, and the specialization of the two halves (hemispheres) of the brain.

The Evolution of Nervous Systems

A very important characteristic of living systems is their ability to respond to and cope with conditions in their external environments. But in order to do this, and to carry on life processes, it is also necessary to maintain an appropriate internal environment. It should be obvious that without these abilities, life would cease to exist.

For humans and other animals above the level of sponges, the nervous system is the primary means for dealing with these problems. Humans have the most complex nervous systems of any species of organism, and are the most successful species on earth. We dominate all other organisms—often to our disadvantage—and successfully occupy a greater variety of environments than any other species.

Many animals possess sophisticated nervous systems, but we must be aware that this is not necessary for biological success. Plants have no nervous tissue whatsoever, yet they respond to environmental conditions—they grow, flower in spring, reproduce, process light energy—and are not only very successful, but are essential for the existence of all other life on earth. Single-celled organisms have no nervous tissue either, but they also are responsive to environmental conditions. They move around, avoid unfavorable conditions, reproduce, and discriminate between food and nonfood items.

Nervous systems first appear in animals of the phylum Cnidaria (Coelenterata)—hydras, jellyfish, and their relatives. In hydras the nervous "system" is a network of nerve cells; there are sensory cells in the external and internal surfaces (Figure 9.1). These nerve nets merely transmit impulses in all directions, out from the point of stimulation (where the hydra is touched or poked), and cause the hydra to contract away from the stimulus. In jellyfish the system is only slightly more complicated, and response to stimulation is similar. This type of nerve arrangement and function exists in

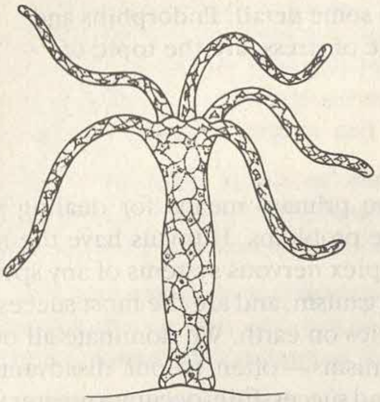


FIGURE 9.1 Nerve net of hydra, phylum Cnidaria. There is no concentration of nervous tissue. The actual neurons are much smaller and more numerous than indicated by the illustration.

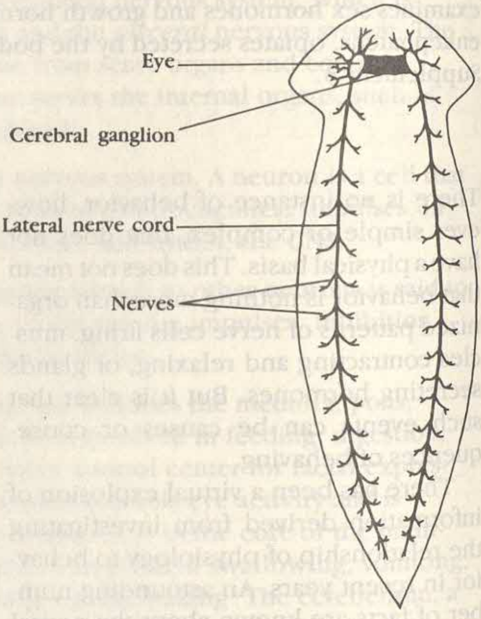


FIGURE 9.2 Nervous system of planaria, phylum Platyhelminthes. Nerve cells are bundled in lateral branching nerves and concentrated at the anterior ("head") end of the body, forming a brain and simple eyes.

higher animals in nerve plexuses which control generalized movements, such as digestive movements in the gut.

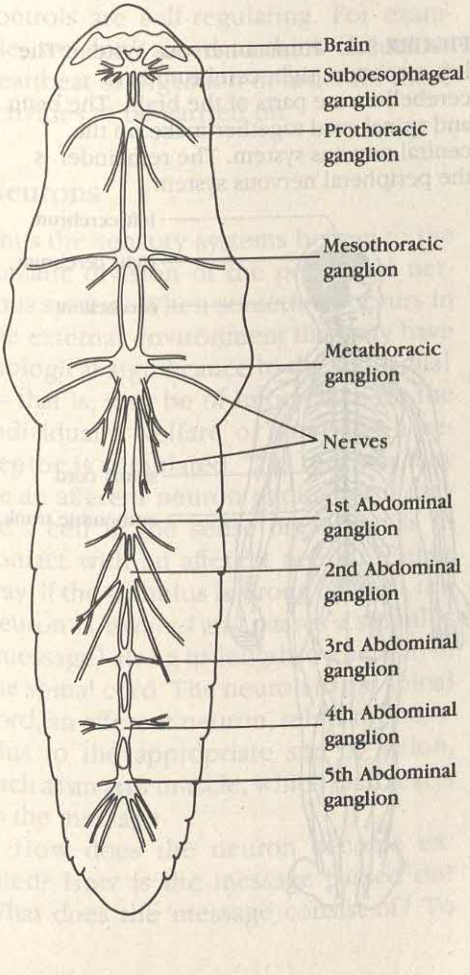
For organisms that move through their environment with one end of the body leading the way it is useful to have the major sensory apparatus, and thus a concentration of nervous tissue, located at the end that meets the environment first. The next more complex phylum, Platyhelminthes, flatworms, is the first in the evolutionary sequence of animals to have that adaptation. Free-living flatworms, such as *Planaria,* display three features that are forerunners of the nervous systems in the highest animals, including the arthropods with insects at the top on one evolutionary branch, and the **vertebrates** with humans at the top on the other.

Flatworms have a concentration of nerve tissue in the forward end of the body—a simple brain (Figure 9.2). Just above, on either side, are groups of light-sensitive cells—very simple eyes. And extending toward the rear on either side of the bodies of flatworms are nerves, with concentrations of nerve cells (ganglia) at intervals along their length from which smaller nerves originate.

We will pass over a number of other phyla and beyond the evolutionary branching of animals into the two major higher divisions of the animal kingdom, the protostomes and the deuterostomes. Protostomes include the phyla Mollusca (clams, snails, octopus), Annelida (earthworms), and Arthropoda (insects, crabs, crayfish, spiders). Deuterostomes include the Echinodermata (starfish) and Chordata (mainly vertebrates—fish, amphibians, reptiles, birds, and mammals). The distinction between protostomes and deuterostomes is primarily based on differences in embryo development. Insects are the most highly evolved protostomes, and mammals are the most highly evolved deuterostomes.

Both arthropods and vertebrates have large brains and very complex nervous systems that are capable of sensing and processing a variety of environmental stimuli, and of reacting in sophisticated ways. Complex social and other behaviors reach adaptive peaks in insects, and in humans. Insects are the most successful animal *group,* but humans are by far the most successful *species.*

FIGURE 9.3 A grasshopper, phylum Arthropoda, has a very complex nervous system. There is a large and complex brain. The ganglia are smaller concentrations of nerve cells that control various parts of the body; for example, the suboesophageal ganglion, just below and behind the brain, controls the jaws and other parts of the mouth..



The basic plan in both is essentially the same as that in flatworms, but the nervous system of insects (Figure 9.3) is far more sophisticated than that of flatworms, and that of humans strikingly more sophisticated than that of insects. Both have a complex brain in the head and a central nerve cord (double in insects) extending back through the body, from which nerves originate and service all parts of the head, body, and appendages. The variety of sensory structures is also similar, although their form and construction are often quite different. Finally, the nervous systems of humans and insects function very similarly, which is not surprising considering that the structure and function of their nerve cells are approximately the same.

The basic function and importance of nervous systems are the same for all animals. They detect, analyze, and decode biologically significant information about the environment, the animal itself, and the relation between the two. This includes regulating internal functions, reproducing at an appropriate time and with an appropriate partner, storing and retrieving information, and making decisions.

Structural and Functional Aspects of the Human Nervous System

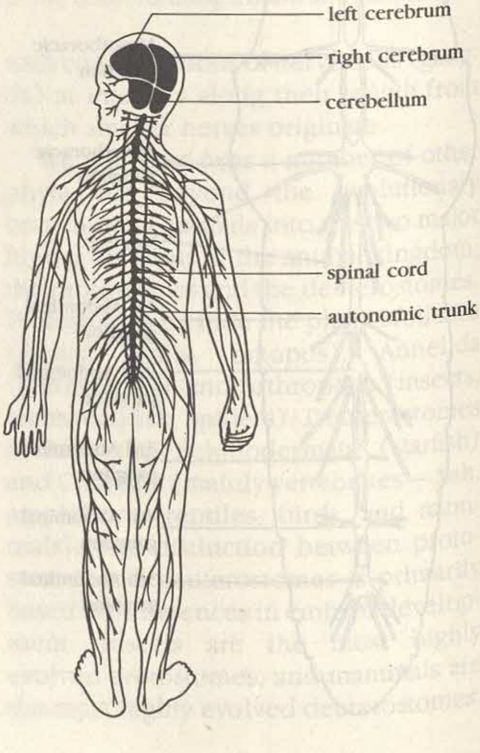
The various sensory systems are information-processing systems, each in its own way detecting features or conditions, and especially changes, in the environment. Each system is specialized; it has evolved to detect only certain types of information, and to ignore or not notice others. Thus our visual system is specialized to detect light waves, while other systems are sensitive to sound waves or temperature changes or contact with other bodies or objects.

There is some variation in sensory abilities among individual humans, and indeed among members of any species. For example, visual and auditory acuity vary among *individuals* of a species, and there is much more variation in sensory abilities among different *species.* Bats hear high-frequency sound waves that are far beyond human perception, and insects cannot see red but can see ultraviolet. Both types of variation—within a species and among species—are to be expected. Within-species variation is at least partly due to the normal genetic variation among individuals. Among-species variations reflect the much greater genetic differences associated with differences in the environmental demands with which the various species must cope. Most species of bats must be efficient at catching flying prey at night; primitive humans needed to be efficient at gathering nuts and grain, digging roots and tubers from the soil, and pursuing and subduing game animals. Our sensory abilities tend to reflect what is adaptive for us, and those of bats reflect what is adaptive for them.

Sensory systems are, of course, parts of nervous systems. The function of the nervous system is to code sensory information from both external and internal sources, to transmit this information to the central nervous system, where it can be processed, and to translate it into appropriate action. The initial coding and most of the transmission is done by nerve cells—**neurons.** **Afferent neurons** transmit impulses to the central nervous system. **Efferent neurons** transmit impulses from the central nervous system to organs or muscles.

The nervous system can be arbitrarily divided into the **central nervous system (CNS),** which consists of the **brain** and **spinal cord,** and the **peripheral nervous system (PNS),** which includes all nervous structures outside the central nervous system (Figure 9.4). The central nervous system is mainly involved in integrative activity. The peripheral nervous system consists of two distinct sets of components, the somatic and the visceral. **Somatic components** are in-

FIGURE 9.4 Human nervous system. The left cerebrum, right cerebrum, and cerebellum are parts of the brain. The brain and spinal cord together make up the central nervous system. The remainder is the peripheral nervous system.



volved in transmitting information from sensory structures and in controlling skeletal muscles. **Visceral components** are involved in transmitting information from (afferent) and to (efferent) smooth muscle, cardiac muscle, and glands. The efferent visceral components are called the **autonomic nervous system (ANS).** The ANS is responsible for a number of functions that are important in life processes, and innervates many of the organs involved, including heart and blood vessels, genitals, and digestive system. This system is called *autonomic* because it operates somewhat autonomously (independently) of the central nervous system; many of the activities it controls are self-regulating. For example, we don't need to think about our heartbeat or digestion in order for these activities to be carried on.

Neurons

Thus the sensory systems belong to the somatic division of the peripheral nervous system. When something occurs in the external environment that may have biological significance to the individual — that is, may be of importance for the individual's welfare or survival—a **receptor** is stimulated. This receptor may be an afferent neuron ending, or it may be a cell in the sense organ that is in contact with an afferent neuron. Either way, if the stimulus is strong enough, the neuron is *excited* and passes a stimulus (message) along its length to a neuron in the spinal cord. The neuron in the spinal cord, an efferent neuron, relays the stimulus to the appropriate site of action, such as an arm muscle, which then reacts to the message.

How does the neuron become excited? How is the message passed on? What does the message consist of? To understand the answers to these questions we need first to examine the structure of a neuron. Then we can look at how a neuron functions.

A neuron (Figure 9.5) is a cell built on the same general plan as other cells in the body. The outer covering of a neuron is the cell membrane, which encloses the cytoplasm and the nucleus. The nucleus contains the genetic information, and the cytoplasm includes the many tiny structures by means of which the cell operates, but with which we are not concerned here.

From the *cell body* of an "average" motor neuron, short, branching **dendrites** radiate out in several directions, and a longer **axon** extends. However, in some sensory neurons, the cell body is on a side branch from the axon (see Figure 9.5). The dendrites detect stimuli and the axon transmits impulses related to those stimuli to other neurons. A majority of axons are covered by a **myelin sheath,** which is constricted at intervals of about two millimeters. The constrictions of the myelin sheath are called *nodes,* specifically the **nodes of Ranvier.** The end of the axon branches and rebranches, and there is a swelling at each branch tip called the **synaptic knob** (Figure 9.6). Within each knob are synaptic vesicles; these are sacs containing chemicals that function as **neurotransmitters,** substances that play an important role in transmitting information from one nerve cell to another.

Now that we have examined the structure of a neuron, we are ready to investigate how it functions. When an environmental stimulus is detected by a dendrite of a sensory (afferent) neuron, the dendrite "decides" whether the message is worth transmitting. This "decision" is generally based on the strength of the stimulus; if the stimulus is

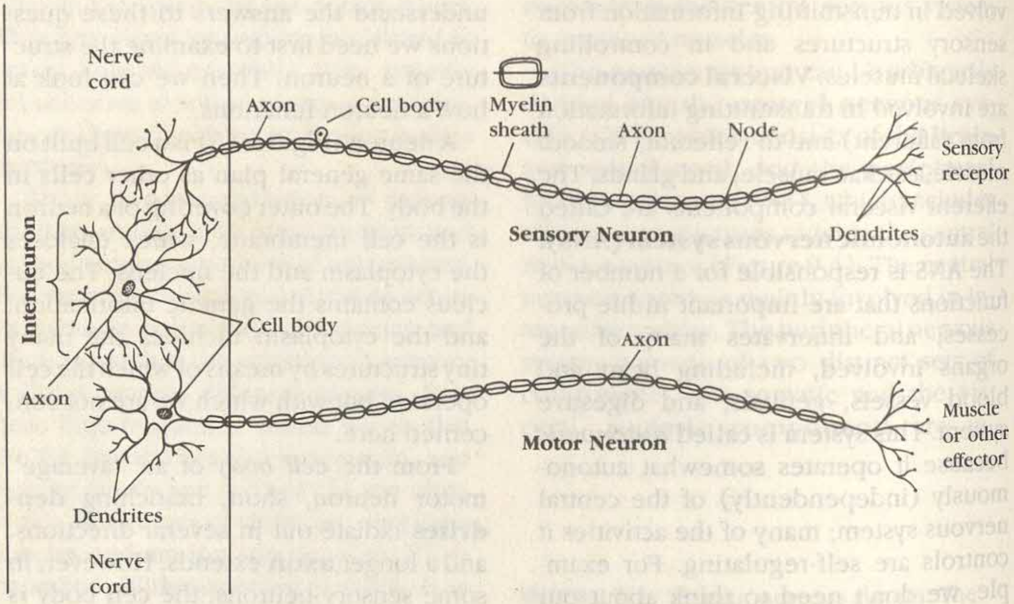


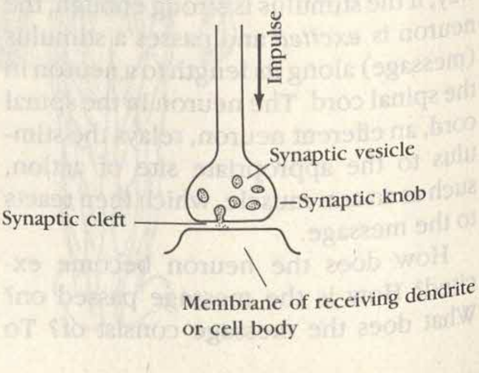
FIGURE 9.5 Three types of neurons. Sensory neurons pass impulses to the central nervous system. Interneurons pass impulses to other neurons. Motor neurons carry impulses out of the central nervous system.

sufficiently strong, a nerve impulse is transmitted.

Whether or not a neuron becomes excited and transmits is an *all-or-none* situation. If the stimulus is of sufficient intensity, the neuron fires; if it is insufficient, firing does not occur. If it does fire, it does so at *full strength,* and the impulses travel at only *one speed* in any one neuron.

So how is the *intensity* of the stimulus detected? Repeated or increasing stimulation can cause repeated firing of a neuron, which gives an indication of intensity. In addition, different neurons fire at different stimulus intensities. Thus a weaker stimulus will cause only one or a few neurons to activate. A stronger stimulus will cause more rapid firing of these neurons, and also will cause additional neurons to become activated. Thus the number and frequency of neuron activations produces a stronger message and provides us with information regarding the intensity of the stimulus, such as the degree of loudness or

FIGURE 9.6 Neurotransmitters are released from the synaptic knob of an axon, cross the synaptic cleft, and may stimulate the neighboring neuron.



brightness, or the extent of damage in the case of pain due to injury.

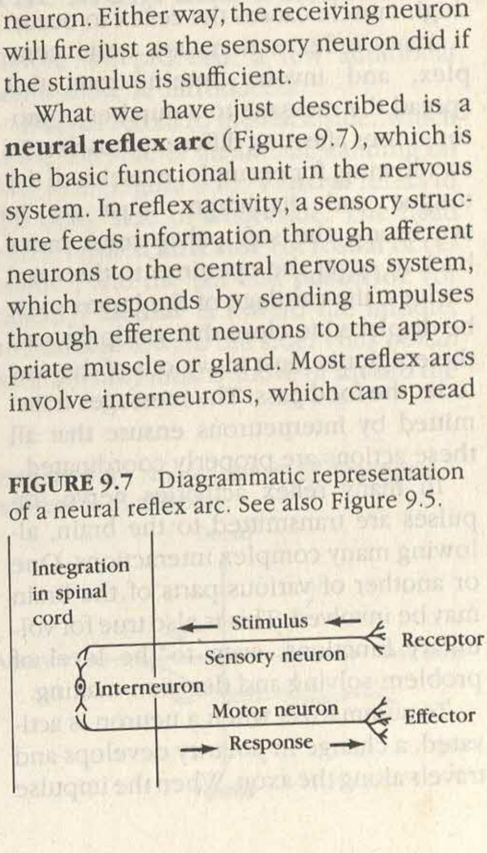
Transmission of a stimulus is electrochemical in nature. If a sufficiently strong stimulus is received by a dendrite, a change occurs in the neuron of which it is a part. In the inactive state, a neuron has a slightly negative electrical charge both internally and on the inside of the cell membrane. In this condition, potassium ions* (K^+) and various negative ions are more concentrated inside the cell membrane, and sodium ions (Na^+) and chloride ions (Cl^-) are more concentrated in the extracellular fluid surrounding the cell. Proteins in the cell contribute to the negative charge inside the cell. Thus in the resting or inactive state the neuron has electrical polarity, similar to the polarity of a flashlight battery, with the positive "pole" outside the cell and the negative "pole" inside. A stimulus acting on a dendrite weakens that polarity, and if the stimulus is strong enough, and the weakening is therefore great enough, the neuron fires—an impulse is initiated. With the reduction of negative charge the neuron and its cell membrane become depolarized, and sodium ions pass through the cell membrane at the base of the axon. This is the beginning of a wave of **depolarization** in other words a nerve impulse. As the impulse flows along the axon, the portion of the axon immediately ahead of the impulse, toward the synaptic knobs, becomes depolarized, and the portion of the axon immediately behind the impulse, toward the cell body, repolarizes and returns to the inactive state. When the impulse reaches the synaptic knobs of the sensory neuron, sacs of neurotransmitter within the knobs move to the cell membrane and release the neurotransmitter substance (see Figure 9.6). The neurotransmitter crosses the **synaptic cleft** and combines with receptor sites on the receiving neuron's dendrite, stimulating the receiving neuron.

The "message" has now crossed the **synapse**—the functional connection between two neurons. A synapse includes the **presynaptic membrane,** which is a portion of the cell membrane at the tip of the synaptic knob of the transmitting neuron; the *synaptic cleft;* and the **postsynaptic membrane**—a portion of the cell membrane at the tip of the dendrite of the receiving neuron.

The receiving neuron may be a **motoneuron** (efferent neuron) in the spinal cord, such as one whose axon extends to and stimulates a skeletal muscle or a gland; or it may be an **interneuron,** which may pass the stimulus to another neuron. Either way, the receiving neuron will fire just as the sensory neuron did if the stimulus is sufficient.

What we have just described is a **neural reflex arc** (Figure 9.7), which is the basic functional unit in the nervous system. In reflex activity, a sensory structure feeds information through afferent neurons to the central nervous system, which responds by sending impulses through efferent neurons to the appropriate muscle or gland. Most reflex arcs involve interneurons, which can spread

FIGURE 9.7 Diagrammatic representation of a neural reflex arc. See also Figure 9.5.



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* An **ion** is an atom or group of atoms that carries a positive or negative charge.

the message to several efferent neurons and thus allow for more complex reflex activity.

The well-known knee-jerk reaction is a familiar example of simple reflex arc activity. A tap on the tendon below the knee cap stretches the thigh muscle slightly. This is detected by sensory cells in the muscle, which transmit a stimulus through the femoral nerve to the spinal cord, where there is a direct synapse with efferent neurons. The result is an immediate efferent transmission that causes contraction of the thigh muscle and a jerking forward of the lower leg. The function of this reflex under natural conditions is to prevent the collapse of the leg when the knee is bent and body weight is on the leg, as in running, or when a blow is struck to the back of the knees; in both cases the stretching of the thigh muscle causes the reflex to occur.

Many reflex actions are quite complex, and involve interneurons that spread the message to a number of motoneurons affecting different muscles. In swallowing, for example, muscles of the tongue and diaphragm must act in synchrony, the soft palate must move back to cover the openings to the nasal cavities, the cartilage of the larynx must be displaced to close the windpipe, and the epiglottis must move out of the way to let the food pass. The messages transmitted by interneurons ensure that all these actions are properly coordinated.

In many reflex activities nerve impulses are transmitted to the brain, allowing many complex interactions. One or another of various parts of the brain may be involved. This is also true for voluntary functions, even to the level of problem-solving and decision-making.

To summarize, when a neuron is activated, a change in polarity develops and travels along the axon. When the impulse reaches the terminal knob, neurotransmitters are released and stimulate the next neuron. If the stimulation is sufficient, that neuron also fires.

After an impulse passes any part of a neuron, that part returns to the inactive state. The period of time involved for this return to normal is called the **refractory period,** which consists of two parts. The **absolute refractory period** lasts from 0.5 to 2 milliseconds, and the neuron cannot fire during this period, no matter how strong the stimulus, because it is already in the process of firing. Following the absolute refractory period is the **relative refractory period,** during which the **threshold** for firing, the level of stimulation required to cause firing to occur, is a bit higher than normal. The relative refractory period may last less than a millisecond, but firing can occur during this period if the stimulus is sufficiently strong or is increasing in intensity.

Thus far we have ignored the functioning of the myelin sheath in impulse transmission. Large-diameter axons typically have a myelin sheath. The presence of a myelin sheath greatly increases the speed of transmission, with the fastest impulse travelling approximately 100 meters per second. The myelin sheath acts as insulation, and the impulse is able to jump from node to node — from one lightly insulated area to the next — which is much faster than simply traveling along the axon.

Excitation and Inhibition

We have already discussed what is involved in excitation of a neuron. A neurotransmitter is released from the synaptic knob of a neuron. This causes the membrane of the receiving neuron to become depolarized, so that it is permeable to — allows the passage of —

sodium ions. This depolarization is called the **excitatory postsynaptic potential (EPSP).** If the EPSP is sufficiently strong, depolarization spreads until it reaches the cell body of the neuron, and an impulse is generated down the axon. From there the impulse can be transmitted to another neuron through the same process.

If all neurons responded to stimulation by transmitting impulses to neighboring neurons, it is probable that the brain would experience a runaway increase in stimulation, resulting in something like an epileptic seizure. Thus some kind of mechanism for inhibiting neural activity is necessary. Many receiving neurons respond to certain neurotransmitters by becoming **hyperpolarized:** the membrane of the receiving neuron becomes less permeable to sodium ions. In effect, this raises the threshold of the receiving neuron and greatly reduces the probability that it will fire, resulting in what is called the **inhibitory postsynaptic potential (IPSP).**

In some cases the same neurotransmitter can lead to an IPSP or an EPSP, depending on the kind of receiving neuron. In other cases the same neuron may produce either an IPSP or an EPSP depending on the kind of neurotransmitter, or combination of neurotransmitters, it receives.

To appreciate just how complex neural transmission can be, consider the following:

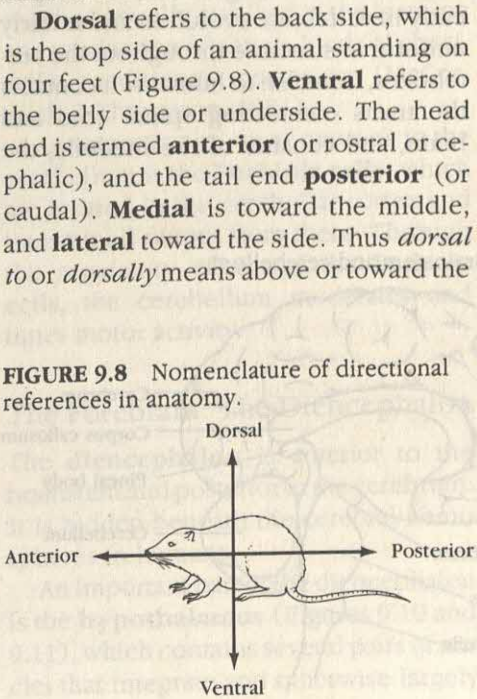
1. The dendrites of a single neuron may synapse with the synaptic knobs of several adjacent neurons.
2. Neurons may vary in the kinds of neurotransmitters they release when firing.
3. EPSPs and IPSPs produced in different dendrites of a neuron can act in conjunction to increase or decrease the likelihood that the receiving neuron will conduct an impulse. This is known as **spatial summation,** because the excitatory or inhibitory effect produced in one dendrite is summed with those produced in other dendrites in a positive or negative fashion.
4. The frequency with which a neuron fires also can affect the probability that the receiving neuron will conduct an impulse. This is called **temporal summation,** because the time interval between impulses received will make an EPSP or IPSP either more or less likely in a receiving neuron.

The Brain and Behavior

Before we proceed, a few additional terms must be introduced.

Dorsal refers to the back side, which is the top side of an animal standing on four feet (Figure 9.8). **Ventral** refers to the belly side or underside. The head end is termed **anterior** (or rostral or cephalic), and the tail end **posterior** (or caudal). **Medial** is toward the middle, and **lateral** toward the side. Thus *dorsal to* or *dorsally* means above or toward the

FIGURE 9.8 Nomenclature of directional references in anatomy.



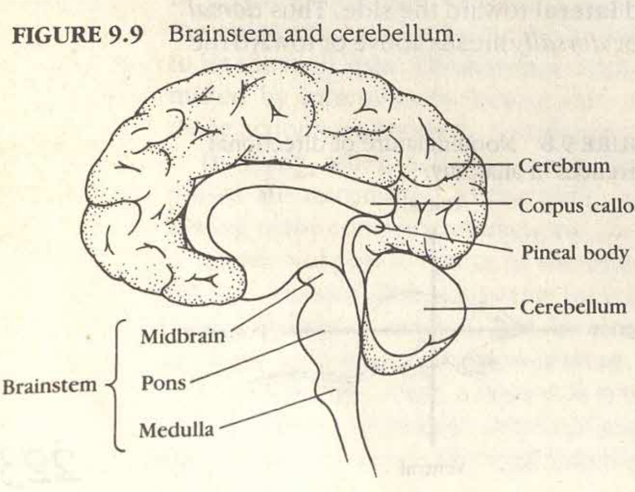
back side; *ventral to* or *ventrally* means beneath or toward the belly side, and so forth.

A **nerve** is a bundle of axons outside the central nervous system. A **ganglion** (plural *ganglia*) is a group of neuron cell bodies that appears as a swelling on a nerve; thus ganglia in vertebrates are outside the CNS. A **tract** is a bundle of axons within the CNS. *Ascending* tracts carry impulses anteriorly and *descending* tracts carry impulses posteriorly within the CNS. A group of neuron cell bodies within the CNS is called a **nucleus** (plural *nuclei*). Ganglia and nuclei usually include the cell bodies of functionally related neurons, and thus the nerves or tracts extending from them usually contain functionally related neurons.

The Brainstem

The **brainstem** (Figure 9.9) developed early in vertebrate evolution and is fairly uniform in structure throughout the vertebrates, from fish to humans. It contains the tracts connecting spinal cord and brain, and consists of the medulla, the pons, the midbrain, and the reticular formation, which is in the core of the brainstem. The brainstem contains mechanisms that exert control over many vital physical and psychological functions.

FIGURE 9.9 Brainstem and cerebellum.



The Medulla The **medulla** is the posterior portion of the brain, where transition from spinal cord to brain occurs. The numerous tracts, very regular throughout the spinal cord, begin to undergo rearrangement here, the white and gray areas becoming intermingled. This is also where the tracts cross over, with the result that one side of the brain controls the opposite side of the body; any adaptive advantage such an arrangement might offer has yet to be discovered. The medulla is involved in feeding, digestion, breathing, head and shoulder movement, and control of the heart.

The Pons The **pons** is a further continuation of the brainstem. Nuclei in the pons play a major role in controlling facial expression, feeding, hearing, and balance.

The Midbrain The most anterior portion of the brainstem is the midbrain. It is relatively short and maintains the tubular structure of the spinal cord (discussed in Supplement 1). Control of eye activity is located in the midbrain. In vertebrates other than mammals, the dorsal surface of the midbrain is expanded to form the optic lobes, which are the primary center for visual perception in those animals. In mammals, the optic lobes are reduced to a pair of small swellings, the **superior colliculi,** which contain important relay nuclei for the visual system; below these are another pair of swellings, the **inferior colliculi,** which are important relay nuclei for the auditory system and possibly are involved in coordinating auditory reflexes. In mammals the perception of visual information takes place mostly in higher centers of the brain, which tells the animal *what* the visual object is, while the midbrain tells the animal *where* in space the visual object is located.

The Reticular Formation A diffuse, complex mixture of small many-branched neurons and nuclei form a net-like structure called the **reticular formation.** This forms the core of the entire brainstem, extending from the spinal cord to the thalamus, but it is larger in the midbrain. It receives and integrates information from the afferent fibers of the cranial nerves, and includes nuclei and "centers" such as those involved in swallowing, vomiting, respiration, and cardiovascular functions. The reticular formation can be divided into descending systems that facilitate or inhibit efferent neurons of the PNS, and ascending systems that affect higher centers such as the thalamus, and other structures in the **cerebral cortex.** The reticular formation plays an important part in regulating sleep and waking, as well as alertness and attention. Destruction of the midbrain reticular formation, or the severing of its ascending tracts to the cerebral cortex, produces a comatose state. Sleeping sickness, in both its viral and protozoan forms, affects the reticular formation.

The Cerebellum

The **cerebellum** (see Figure 9.9) is small and smooth in primitive fish and in amphibians, and much larger but still smooth in reptiles. In mammals, however, not only is it still further enlarged, but lobes and convolutions are added. In humans the gray matter is in the two-millimeter-thick surface layer, the cerebellar cortex, which covers the inner white matter. This is the reverse of the arrangement of the gray and white matter in the spinal cord. Gray matter is composed of cell bodies, and white matter of axons.

The cerebellum is thought to be the part of the brain that first became specialized for sensory-motor coordination. The evolutionarily older parts of the cerebellum control equilibrium (balance) and posture. The newer part, which first appeared in reptiles, is particularly important in controlling voluntary locomotor movement. In mammals the cerebellum controls equilibrium, posture, and motor coordination. It does not initiate muscle actions, but rather processes and coordinates those initiated elsewhere so that movement is smooth. Removal of the cerebellum results in jerky, uncoordinated movements. There is also evidence that parts of the cerebellum may be centrally involved in the learning and production of certain kinds of classically conditioned responses (McCormick & Thompson, 1984).

An important group of neurons in the cerebellum is the **Purkinje cells,** which are located in the cerebellar cortex and transmit all output from there. Through the regulatory effects of the Purkinje cells, the cerebellum moderates and tunes motor activity.

The Forebrain: The Diencephalon

The **diencephalon** is anterior to the brainstem and posterior to the cerebrum. It is hidden beneath the cerebral hemispheres in humans.

An important part of the diencephalon is the **hypothalamus** (Figures 9.10 and 9.11), which contains several pairs of nuclei that integrate and otherwise largely

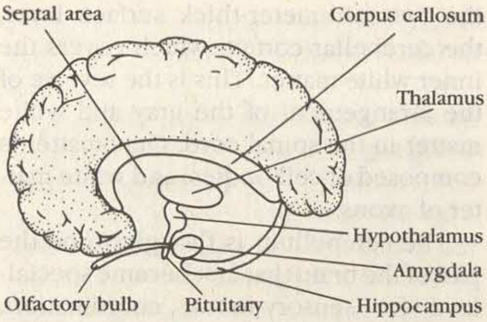


FIGURE 9.10 Longitudinal section of human brain showing the spatial arrangement of some major features of the limbic system, plus the thalamus, hypothalamus, and pituitary.

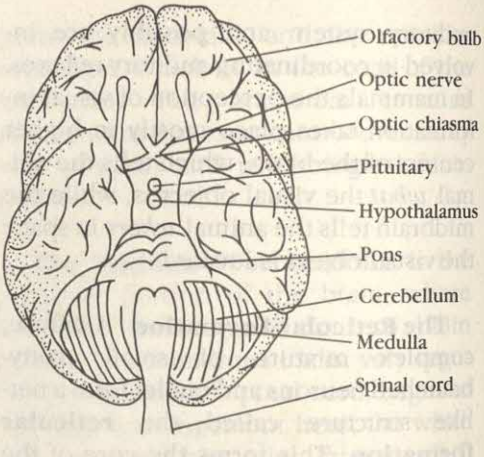


FIGURE 9.11 Ventral view of human brain.

control the autonomic functions of the body. There are two centers for each function, one for facilitation and the other for inhibition, reflecting the dual nature of the autonomic system.

The hypothalamus monitors various aspects of the internal environment, such as the temperature and chemistry of the blood. When conditions are not optimal, the hypothalamus initiates correction by stimulating other parts of the nervous system and the **pituitary gland,** which is associated with the production of various hormones. These stimuli result in adjustments, either carried out internally or made by stimulating behaviors to acquire necessary materials from the external environment, such as food or water. The hypothalamus is the major link between the nervous system and the hormonal systems of the body through its effects on the pituitary gland (see Figures 9.10 and 9.11).

In addition to its important role in regulating the internal environment, the hypothalamus (together with certain structures in the limbic system) has a great deal to do with *emotional* behavior. For example, mild electrical stimulation of certain parts of the hypothalamus appears to bring about intense pleasure, while stimulation of other parts produces anger and rage. Typically, the cerebral cortex keeps the hypothalamus from "losing control" over emotional responses. Cats in which the neural connections between the hypothalamus and cerebral cortex have been severed will direct full-blown rage responses toward anyone who comes near them (Bard, 1928).

The **thalamus** (see Figure 9.10) is located above the hypothalamus. One group of nuclei in the thalamus projects motor fibers posteriorly, while a different group receives information from various senses—taste, touch, vision, hearing, pain—and relays it through sensory tracts to higher centers in the brain.

The **epithalamus** is the narrow dorsal portion of the diencephalon. The **pineal body** is located along its midline in humans. In four-footed animals the pineal body has an endocrine function, secreting the hormone melatonin. Melatonin secretion increases during periods of darkness, and decreases when the animal is exposed to light. Melatonin is involved in relations between changing day lengths and animal activities such as reproduction and migration.

Until recently it was thought the pineal body had no effect in humans. It was suggested that we had probably evolved to the point where we operate independently of controls such as the pineal body exerts on other vertebrates. However, Alfred J. Lewy, Richard J. Wurtman, and others who have been working on the problem are finding that light intensity, particular wavelengths, and the duration of exposure to light may have rather profound influences on our mental and physical health and activity (Hellman, 1982). For example, light affects how our immune system operates, and winter depression experienced by one patient has been successfully treated by exposing him to high-intensity, broad-spectrum light in early mornings and late afternoons, artificially lengthening his "day." A number of seasonal patterns that have been reported for humans, including variations in suicide and pregnancy rates, may be at least partly due to the effects of day length. Women in northern Finland, for example, experience a higher rate of pregnancy in summer, when their melatonin levels should be at their lowest.

The Forebrain: The Telencephalon

The Limbic System The **limbic system** is a group of structures that form a sort of ring around the lower part of the forebrain (see Figure 9.10). They are close together and interconnected in such a way that impulses can move from any one structure to any other in the limbic system through relatively few synapses.

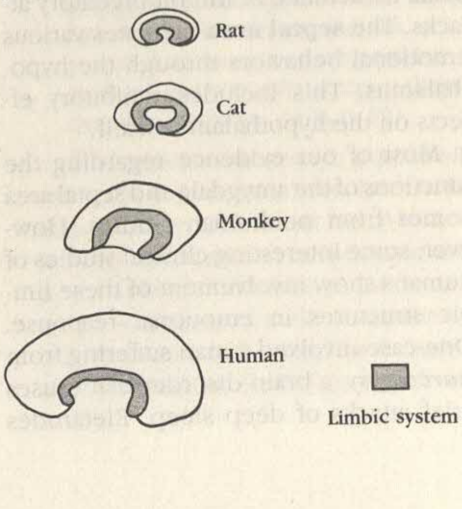
Because it was discovered early in the study of brain function that the limbic system received olfactory information, it was for some time called the "smell brain." In fact, it has been suggested that the limbic system was the earliest form of forebrain to develop in some unknown ancestral vertebrate, and that along with olfactory detection it also may be involved in appropriate *responses* to odors, such as approach, attack, escape, and mating:

> Essentially the entire forebrain of the crocodile is limbic brain. . . . the crocodile is an intact, functioning organism responsive to sensory stimulation, that engages in a variety of behaviors, including the "four Fs"—fleeing, feeding, fighting, and reproductive behavior (Thompson, 1975, p. 388).

Even in "lower" *mammals,* such as rabbits, the limbic system constitutes the major portion of the brain (Figure 9.12).

Some parts of the limbic system still function in olfaction, but most of its structures have nothing to do with the sense of smell. Other important func-

FIGURE 9.12 Approximate extent of the limbic system in the brains of various mammals. Relative sizes of brains are not proportionate.



tions of the limbic system include involvement in emotion, motivation, arousal, and memory.

Unfortunately, the available information regarding the limbic system is not completely clear, and there appears to be substantial functional overlap and interdependence among the various structures. Here we will mention several important limbic structures, and some of their functions.

In most vertebrates the anterior-most portions of the **telencephalon** are the **olfactory bulbs.** They are quite prominent extensions of the **cerebrum**—the uppermost part of the brain—in fish, amphibians, reptiles, and primitive mammals. As we proceed from primitive to more advanced mammals, the olfactory bulbs begin to be overgrown by the expanding cerebral hemispheres, and in the primates they are well beneath the anterior portion of the cerebral hemispheres (Figure 9.12). The olfactory bulbs function in the sense of smell, a very old sense from an evolutionary perspective.

The **amygdala** is involved in alerting and arousing and in various aggressive and escape behaviors. Through the hypothalamus, the amygdala can stimulate defensive attack and escape; it also appears to facilitate or inhibit predatory attacks. The **septal area** mediates various emotional behaviors through the hypothalamus. This includes inhibitory effects on the hypothalamus itself.

Most of our evidence regarding the functions of the amygdala and septal area comes from nonhuman studies. However, some interesting clinical studies of humans show involvement of these limbic structures in emotional response. One case involved a man suffering from *narcolepsy,* a brain disorder that causes brief attacks of deep sleep. Electrodes were implanted at various sites in the limbic region of this particular patient, and he was given a portable control panel with which he could stimulate any of the sites containing an electrode. The hope was that stimulation of one or more sites would offset the narcoleptic attacks. Some of the results of this interesting case study are summarized by Robert Heath (1972):

> Stimulation to the septal region was the most rewarding of the stimulations and, additionally, it alerted the patient, thereby combatting the narcolepsy. By virtue of his ability to control symptoms with the stimulator, he was employed part-time, while wearing the unit, as an entertainer in a night club.
>
> The patient's narcolepsy was severe. He would move from an alert state into a deep sleep in a matter of a second. Recognizing that button pressing promptly awakened him, fellow patients and friends occasionally resorted to pushing the button if he fell asleep so rapidly that he was unable to stimulate himself.
>
> The patient, in explaining why he pressed the septal button with such frequency, stated that the feeling was "good"; it was as if he were building up to a sexual orgasm. He reported that he was unable to achieve the orgastic end point, however, explaining that his frequent, sometimes frantic, pushing of the button was an attempt to reach the end point. This futile effort was frustrating at times and described by him on these occasions as a "nervous feeling" (pp. 119–20).

The **hippocampus** appears to play a role in learning and memory. For example, Berger, Alger, and Thompson (1976) attempted to classically condition the nictitating membrane response of rabbits while observing neural activity in the hippocampal region. The nictitating membrane is a thin layer of tissue that is capable of extending across the eyeball. This membrane is found in many animals other than rabbits, but not in humans. A puff of air directed at the eye (an unconditioned stimulus — UCS) will cause the characteristic extension of the nictitating membrane (the unconditioned response — UCR). Berger et al. paired a tone (a neutral stimulus — NS) with the airpuff (UCS) over several trials and found evidence of conditioning; that is, the tone presented alone (a conditioned stimulus — CS) was now capable of eliciting the membrane response (the conditioned response — CR). Of greatest interest, however, was what was happening in the hippocampus. Microelectrode recordings showed sharp increases in hippocampal activity with successive conditioning trials, until the tone alone (CS) began to be associated with high rates of firing of hippocampal neurons. Prior to conditioning the tone alone produced neither a membrane response nor any increase in hippocampal activity, and control animals that received *unpaired* presentations of the tone and the puff of air showed no conditioning and no evidence of increasing activity in the hippocampus. This correlation between conditioning and neural activity suggests a potentially important role of the hippocampus in the storage of information in memory.

Clinical case studies of humans with injuries to the hippocampal region, and observations of monkeys with hippocampal lesions (Zola-Morgan & Squire, 1982) also point to this part of the limbic system as important in the storage of information. Consider the following:

> At the age of 16, HM, who had been normal up to then, began to suffer from epileptic attacks, which, on account of their intensity and frequency, made all normal activity impossible for him. At the age of 27, he submitted to a mesial temporal bilateral resection performed by Scoville. This operation, which spared the entire temporal neocortex, consisted of a total excision of the internal part of the temporal lobe, beginning at the apex of the temporal lobe and destroying the anterior two-thirds of the hippocampus, the uncus, and the amygdaloid nuclei of both sides. After a period of confusion, a very severe memory disorder became established and had remained practically unchanged ever since. This intelligent patient had no [language problems]. He suffered, however, from such a gradual forgetting that he retained practically nothing of the events of his current life. For instance, 6 months after his operation, his family moved into another house on the same street; he could never remember his new address and always returned to the old house. His parents moved again a few years later, and, although he seemed to know that he had moved, he could not remember the address. He could not remember where things belonged; he mowed the lawn rapidly, but had to ask his mother each time where the mower was kept. He did the same puzzles day after day and reread the same magazines. He did not recognize or know the names of his neighbors, and invariably treated them as strangers. He managed to retain three figures for about fifteen minutes, provided he was not interrupted by anything and was able to repeat them mentally (Barbizet, 1970, p. 59).

Thus the limbic system plays numerous roles in our daily lives, both in body maintenance and in our behaviors. Certainly it has proven to be much more than a "smell brain." Moreover, the functions we have discussed make it apparent that the limbic system could have been the earliest form of forebrain in the vertebrates.

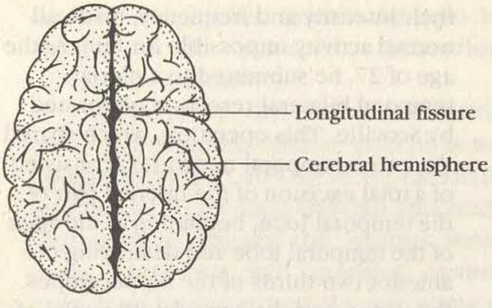


FIGURE 9.13 Dorsal aspect of the human brain. Cerebral hemispheres are divided by longitudinal fissure.

The Cerebral Hemispheres When we look at the human brain, most of what we see is the **cerebral hemispheres,** separated by the **longitudinal fissure** (Figure 9.13). Communication between the hemispheres is through a large group of fibers, the **corpus callosum** (see Figures 9.9 and 9.10). Generally speaking, there is a direct correlation between the evolutionary position of an animal and the relative size and development of the cerebral hemispheres. In fish they are smaller than the brainstem, and they become progressively larger as we move through amphibians and reptiles to mammals.* The same thing happens as we move further, from primitive mammals to the primates.

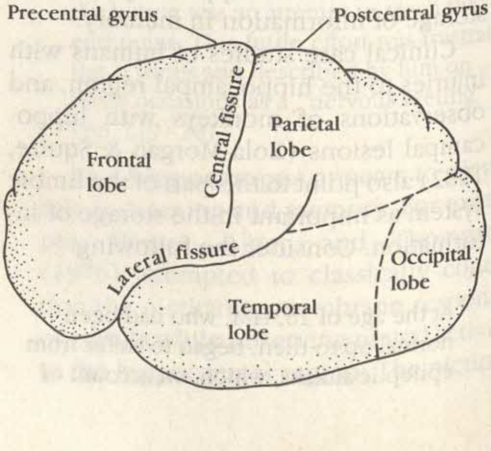
The outer layer of the cerebral hemispheres is the **cerebral cortex,** the most recent evolutionary development of the vertebrate nervous system. The cerebral cortex of each hemisphere is arbitrarily divided, according to function, into lobes that are sometimes separated by clefts called fissures.

The anterior portion of the cerebral cortex of each hemisphere is the **frontal lobe,** which is separated from the **parietal lobe** by the **central fissure** (Figure 9.14). The posterior portion of the cerebral cortex is the **occipital lobe.** The **temporal lobe** is on the side near the temples; it is separated from the frontal lobe, and partially separated from the parietal lobe, by the **lateral cerebral fissure.**

The cerebral cortex has sensory areas, motor areas, and association areas. Some of these are indicated in Figures 9.15 and 9.16. The **sensory areas** receive data from the sense organs. The **motor areas** can control skeletal muscles, often indirectly through other parts of the brain. **Association areas** are located in virtually all parts of the cerebral cortex; some of these appear to function in learning, intellect, memory, and artistic and creative abilities.

It is noteworthy that both the sensory and motor areas for the hand and for the mouth are so extensive (Figure 9.15). Our evolutionary success has been strongly affected by our ability to manip-

FIGURE 9.14 Lobes and major fissures of human brain, left lateral view.



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* In mentioning the various vertebrate groups we have ignored birds. They are important and interesting but are not relevant to evolutionary consideration of humans or other mammals. Mammals and birds evolved from different reptilian lines—birds from the same line as the ornithischian dinosaurs, and mammals from a separate line, the synapsids.

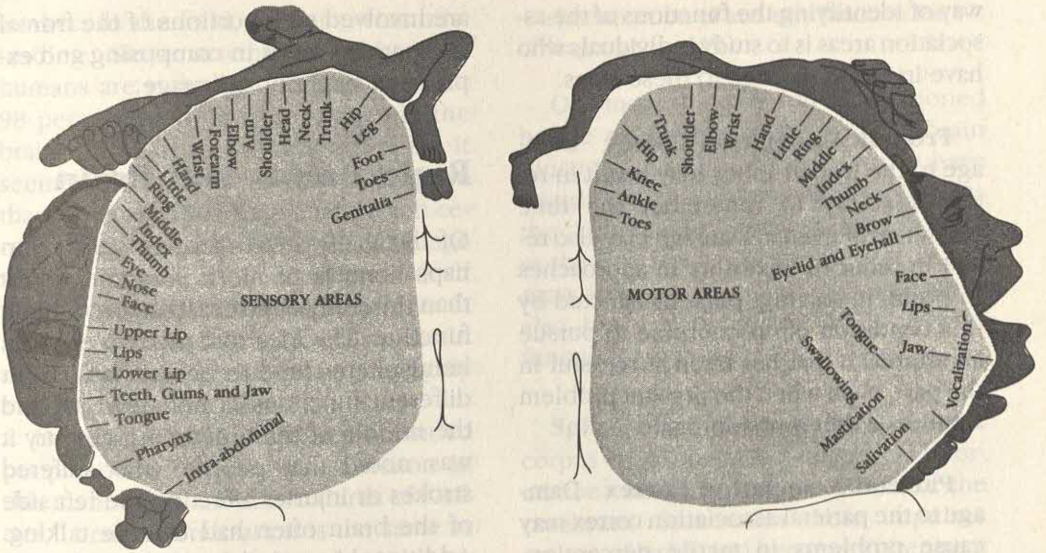


FIGURE 9.15 The sensory and motor areas of the human cerebral cortex. Note the relationships between the importance of a structure and the area of cerebral cortex involved. The sensory cortex is in the postcentral gyrus, the motor cortex in the precentral gyrus.

ulate objects, and by our ability to communicate by means of complex speech. The association areas of the cerebral cortex were also quite important in our advancement.

Relative proportions of sensory-motor and association areas of the cerebral cortex of some mammals are shown in Figure 9.16. Association areas are more extensive in humans than in other animals. This suggests that human association areas may be involved in mental abilities that are less well developed or that are missing in so-called lower animals—for example, complex problem-solving and reasoning skills. One

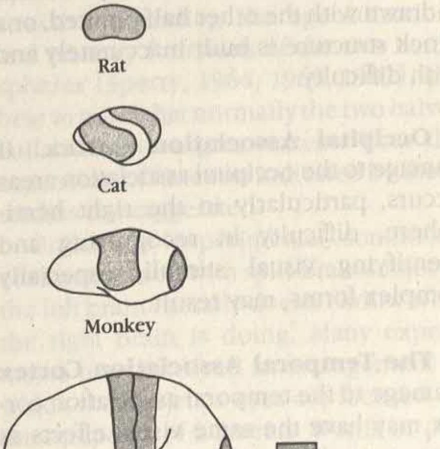


FIGURE 9.16 Relative sensory-motor and association areas of the brains of various mammals. Relative sizes of brains are not proportionate.

way of identifying the functions of the association areas is to study individuals who have incurred damage to these areas.

Frontal Association Cortex Damage to the frontal lobes may result in reduced ability to remember the time sequence of events. Damage may also result in reduced flexibility in approaches to problem-solving; persons affected by this condition often continue to pursue an approach that has been successful in the past, even when the present problem requires a different approach.

Parietal Association Cortex Damage to the parietal association cortex may cause problems in tactile perception, particularly in the recognition of shapes while blindfolded. Perception of one's body may also be reduced, with results such as caring for only one side of the body when dressing or shaving. There may be problems in comprehending and/or composing either written or spoken language. Other sensory-motor tasks may be adversely affected—for example, when a person with damage in this area copies a model, often only one half is drawn with the other half omitted, or a block structure is built inaccurately and with difficulty.

Occipital Association Cortex If damage to the occipital association areas occurs, particularly in the right hemisphere, difficulty in recognizing and identifying visual stimuli, especially complex forms, may result.

The Temporal Association Cortex Damage to the temporal association cortex may have the same visual effects as damage to the occipital association cortex. In addition, portions of the temporal lobe, particularly of the left hemisphere, are involved with portions of the frontal and parietal lobes in composing and expressing symbolic language.

Right Brain – Left Brain

Of the many areas of brain study, perhaps none is of more general interest than the study of **lateralization** of brain function. The idea that the two cerebral hemispheres tend to be specialized for different functions is not new. Around the middle of the nineteenth century it was noted that people who suffered strokes or injuries affecting the left side of the brain often had trouble talking. Additional knowledge regarding lateralization has been added since, but there is still much more research to be done.

Because of evidence that the left side of the brain is involved in language formulation and interpretation, and fine motor control, nineteenth-century scientists called the left side of the brain the major or dominant hemisphere, the right side the minor hemisphere. Arguments can be made in favor of retaining these designations, based on the high adaptive significance of language abilities and other important functions of the left brain. However, the right brain is primary in functions that are also of high survival value, and we believe such designations as major and minor tend to be misleading, or at least oversimplified.

Before going further, we need to rectify two oversimplifications of our own. First, lateralization is not unique to humans; Andrew and Brennan (1983) note that it has been documented in several species of mammals and birds; it occurs in primates and perhaps in some songbirds. Second, our references to left-brain and right-brain functions, which are similar to references by early workers in the field, are somewhat misleading. Since around 90 percent of humans are right-handed, and in about 98 percent of right-handed people the brain functions as we have indicated, it seemed obvious to scientists of more than a hundred years ago that the left cerebral hemisphere dealt with language and the right hemisphere dealt with . . . well, with something else. It appeared that the right side of the brain must be less advanced, not as highly evolved as the left side.

However, the brains of left-handed people do not necessarily function in this manner. In about two-thirds of "lefties," brain lateralization is the same as in most right-handed people. In some others the functions are reversed; this is especially likely for left-handers whose mothers were left-handed also (at least so it seems—the results of research on handedness are rather uncertain at present). And finally, some left-handed people seem to use both halves of the brain equally. However, for convenience we will use the left-brain and right-brain designations as they apply to the majority of people—somewhere around 95 percent—with apologies to those whose brains function differently.

Recently it has been shown that at least some lateralization of brain function is already present in humans at birth. Hofer (1981) reports that

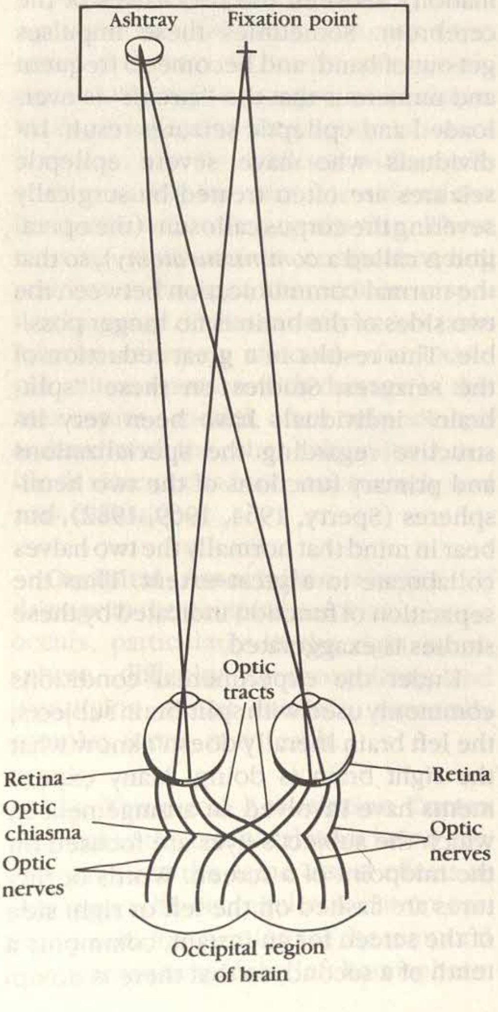
> newborns process sound differently depending on which ear and thus which side of the brain is used. The threshold for the eye-turning response to sound is lower in the right ear, and discrimination of fine differences in sounds is better for speech on the right but is better for nonspeech sounds, such as white noise or music, on the left. Thus, newborns show auditory . . . [preadaptation], and begin life . . . with an early lateral specialization of auditory function for language (p. 119).

One more thing should be mentioned before we go into right- and left-brain function in more detail. You may have heard the left hemisphere referred to as the "think brain," the right hemisphere as the "art brain." The right side *is* primary in many spatial endeavors, but it also has a very important "thinking" function, as we shall see.

Split-Brain Evidence Normally the corpus callosum passes impulses (information) between the two halves of the cerebrum. Sometimes these impulses get out of hand, and become so frequent and numerous that the "circuit" is overloaded and epileptic seizures result. Individuals who have severe epileptic seizures are often treated by surgically severing the corpus callosum (the operation is called a *commissurotomy*), so that the normal communication between the two sides of the brain is no longer possible. This results in a great reduction of the seizures. Studies on these "split-brain" individuals have been very instructive regarding the specializations and primary functions of the two hemispheres (Sperry, 1964, 1969, 1982), but bear in mind that normally the two halves collaborate to a great extent. Thus the separation of function indicated by these studies is exaggerated.

Under the experimental conditions commonly used with split-brain subjects, the left brain literally doesn't know what the right brain is doing. Many experiments have involved an arrangement in which the subject's eyes are focused on the midpoint of a screen. Words or pictures are flashed on the left or right side of the screen for an instant, commonly a tenth of a second, so that there is no opportunity for the eyes to scan the screen. In this way, because of the structure of the eyes, the left brain receives only an image on the right side of the screen, while the right brain receives an image on the left (Figure 9.17). In other experiments an object is placed in the subject's hand, but out of view. The right brain perceives an object held in the left hand, the left brain perceives an object held in the right hand.

FIGURE 9.17 Detection of visual stimuli. The left and right eyes communicate stimuli to opposite sides of the occipital region.



In both types of studies, when either visual or tactile information was received by the left hemisphere (from the right hand or right visual field), the subjects could describe what they saw or felt either verbally or in writing. However, when similar stimuli were presented to the right hemisphere, subjects could not name or verbally describe the stimulus, but most of them could identify a picture or the written name of the stimulus. Furthermore, when the right brain was shown a picture of a cigarette and the subjects were directed to select a *related* object from a group of ten objects, they selected an ashtray, but could not name or describe it.

In another test, the subjects were asked to name a color that was presented to the right brain. The subjects knew beforehand that the color would be either red or green. The subjects' left brains had not seen the color and had to guess at the answer. If a subject made an incorrect guess, the right brain knew the answer was wrong but was unable to make a verbal correction. Instead the right brain would cause the subjects to frown and shake their heads "no" (Gazzaniga, 1967).

A different type of experiment involved arranging several wooden shapes to match a particular model. The right hand (left hemisphere) failed repeatedly, but the right-hemisphere–controlled left hand was successful. This shows the relative spatial ability of the two hemispheres.

These and other similar tests using split-brain patients reveal two important findings: (1) The *separated* hemispheres are "unaware" of each other's activities; and (2) the left hemisphere appears to be specialized for *verbal* ability, the right hemisphere for *spatial* ability.

Left Brain The left brain has been said to process information by verbal and analytic thinking, seeking out isolated and specific details and arranging and considering them in a logical sequence. The left brain is involved in counting and other mathematical computation, marks time, plans step-by-step procedures for solving problems, and plays an important role in decision making based on rules of logic.

Left brain functions also appear to involve emotional states that differ from those of the right brain (Tucker, 1981). In cases where brain damage removes the restraining or balancing influence of the right hemisphere, patients tend to be cheerful, even elated, and accepting of a situation as it exists. They have a positive approach in planning, often indifferent to surrounding circumstances that might interfere or call for some other action.

Right Brain In contrast to the left brain's attention to and even obsession with detail, information processing by the right brain has been characterized as being nonverbal and concerned with the overall picture. It deals with recognition of whole patterns of stimulation, such as faces, melodies, and environmental sounds; it sees things in all their complexity, taken all at once. The right brain recognizes how things exist in space, how the parts go together to make up the whole, and how situations and conditions relate to one another. It can recognize common words and language to some extent, but is more involved with intuition and with insight, as in the sudden perception of relationships that were previously unnoticed, the so-called "Aha!" experience. The right brain dreams, imagines, visualizes, sees imaginary or real things in the "mind's eye," and creates new combinations of ideas. It responds to experiences with emotion. It communicates with gestures when something is too complex to describe verbally.

In contrast to the left brain, right brain activities are sometimes associated with gloomy emotional states. Patients deprived of the normal emotional balance provided by the left hemisphere tend to withdraw, experience fear, indulge in self-denial, and cry without knowing why.

Earlier we argued against calling the right brain the minor hemisphere, because it has functions that are very complex and also of high survival value. Recognition of faces and environmental sounds, and of where things exist in space, are not only important to us today but were essential to our ancestors a few thousand years ago. If you got lost on the way home, or couldn't find your food, or failed to recognize someone who had threatened you with bodily harm, you would feel rather strongly about the value of the right brain.

The Whole Brain Although we have considered specific and mostly separate functions of the two hemispheres, it is useful to examine the way they normally operate—as an integrated whole. The two hemispheres work in a complementary fashion, communicating and cooperating with each other through their connections in the corpus callosum. If one side is damaged, the other can supplement to some extent. The two halves use different modes of highly complex thinking and reasoning. They operate as two minds, two forms of consciousness, that are meshed, reconciled, and integrated through the corpus callosum. Although each hemisphere is specialized for different functions, accurate cognition and balanced states of feeling depend on the smooth integration of the activities of both hemispheres (Levy, 1985).

The Endocrine System

The **endocrine glands** (Figure 9.18) do not form an organ system in the usual sense, but as a group they function somewhat like a nervous system. Each gland controls and integrates bodily functions, and may interact with other glands to coordinate activities. Unlike the nervous system, however, endocrine signals are transmitted by releasing hormones into the blood, and the effects tend to be slower and longer-lasting than those of the nervous system.

Very simply put, a **hormone** is a substance produced by a *special structure* in *one* part of the body that has one or more *specific effects* in *another* part of the body. A hormone produced by a particular endocrine gland has an effect only on a certain target tissue or tissues. For example, one type of adrenal hormone (aldosterone) affects kidney function, while sex hormones influence the development of sex characteristics and, somewhat later, fertility. Thus, while the distribution of hormones in the blood spreads them to all parts of the body, only certain *target-organ cells* in a particular tissue or tissues can respond to any one hormone. An exception is the growth hormone, which affects virtually all cells of the body during growth.

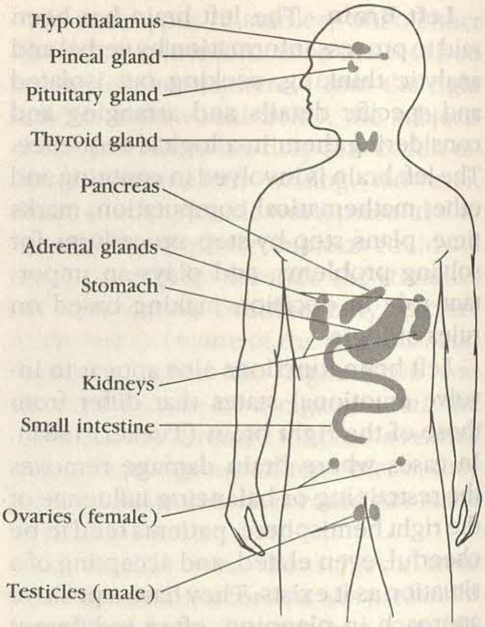


FIGURE 9.18 Endocrine glands of humans.

In a way, the distinction we have made between the nervous and endocrine systems may be misleading. Actually they function as a single system in the sense that the nervous system, especially the hypothalamus, is crucial in controlling the secretion of most hormones, while hormones have profound effects on neural functions and on many behaviors. Further discussion of endocrine system functioning is presented in Supplement 2 of this chapter.

Supplement 1. Development of the Human Nervous System

Now that some aspects of the nervous system have been introduced, we will examine its development in the embryo.

After a sperm has fertilized an ovum, many cell divisions occur, and after a while various tissues begin to differentiate. One of the first is the **neural plate,** a group

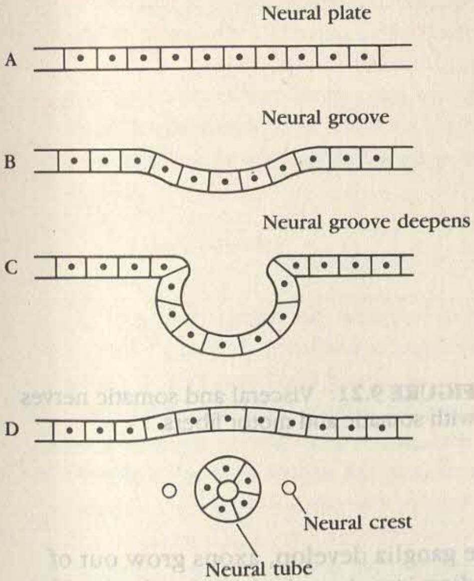


FIGURE 9.19 Successive stages in the development of a chordate nervous system in the embryo.

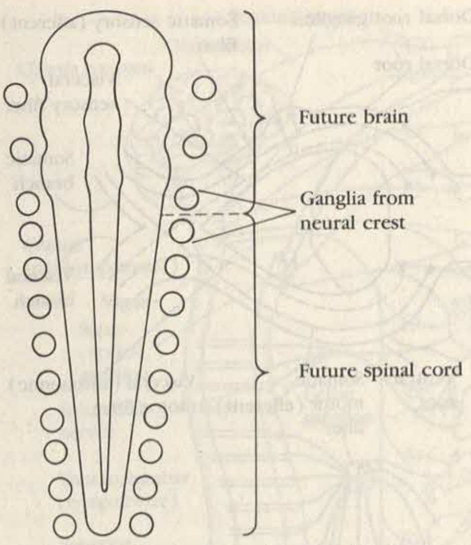


FIGURE 9.20 Neural tube and developing ganglia.

of cells on the dorsal surface of the embryo. This is the beginning of the nervous system (Figure 9.19A). As development proceeds, the neural plate sinks into the embryo, causing a groove to develop, the **neural groove** (Figure 9.19B and C). In the human embryo this occurs about two and a half weeks after fertilization. As the groove deepens it is overgrown by cells dividing along the edges of the groove. At about five weeks the groove has closed, so that the ectoderm (outer surface) is again continuous and the groove has become a tube, the **neural tube** (Figure 9.19D), which then separates from the outer surface. The neural tube is the beginning of the central nervous system.

While the groove is developing, cells along the sides of the groove beneath the outer surface divide to form the **neural crests** (Figure 9.19D). When the neural tube detaches from the ectoderm, the neural crests detach from both the ectoderm and the neural tube. The neural crests will develop into the majority of the peripheral nervous system.

The Peripheral Nervous System

Each neural crest becomes divided into several clumps of cells (Figure 9.20) that ultimately form three groups of ganglia on each side of the body. Some ganglia and some beginnings of nerves are distinguishable in the human embryo at about five weeks. One group, the future *dorsal root ganglia,* gives rise to the sensory (afferent) nerves of the peripheral nervous system, both its somatic and visceral components. These ganglia remain next to the neural tube, which will become the

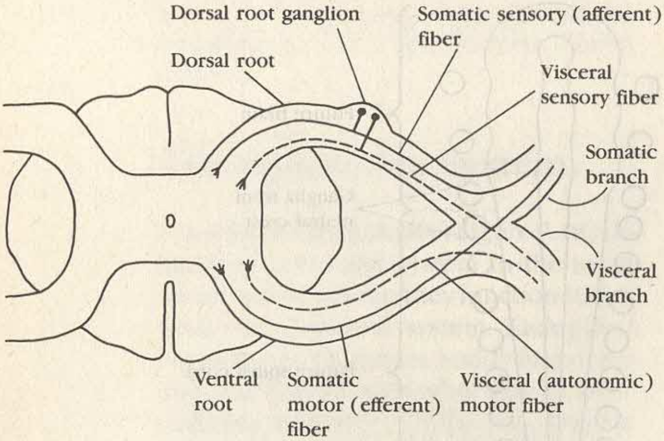

Dorsal root ganglion
Somatic sensory (afferent) fiber
Dorsal root
Visceral sensory fiber
Somatic branch
Visceral branch
Ventral root
Somatic motor (efferent) fiber
Visceral (autonomic) motor fiber

FIGURE 9.21 Visceral and somatic nerves with somatic and motor fibers.

brain and spinal cord. As the neurons in these ganglia develop, axons grow out of the cell bodies and divide, one branch extending into the spinal cord or brain. The outer branch extends to a sensory structure or internal organ where dendrites develop.

The efferent neurons of the peripheral nervous system, somatic and visceral, originate in and grow out of the spinal cord and brain, forming the ventral roots. The afferent nerves (dorsal root) and efferent nerves (ventral root) converge just outside the CNS and are included in the same bundle for some distance; in this way the *cranial* and *spinal nerves* are formed, which then branch into visceral and somatic nerves composed of both afferent and efferent axons (Figure 9.21). The somatic nervous system includes the portion of the peripheral nervous system that transmits information from sense organs and joints to the CNS, and from the CNS to skeletal muscles.

The other groups of neural crest cells give rise to the majority of the autonomic nervous system, which consists of two groups of ganglia and nerves, the **sympathetic** and **parasympathetic nervous systems** (Figure 9.22). These two systems connect with different parts of the CNS, but for the most part they innervate the same organs. Some neural crest cells line up, forming a sort of chain just outside the area where the vertebral column will be, and form the left and right *sympathetic trunks;* this occurs at about six weeks in the human embryo. The sympathetic trunks receive innervation from spinal nerves of the thoracic and lumbar regions of the spinal cord (Figure 9.22). Other sympathetic ganglia move to about halfway between the sympathetic trunks and the organ or gland they will innervate, and receive efferent fibers from the sympathetic trunks.

Those groups of neural crest cells destined to develop into ganglia of the *parasympathetic nervous system* move to become located at or in the organs they innervate. The parasympathetic nervous system receives innervation from the cervical and sacral regions of the spinal cord (Figure 9.22).

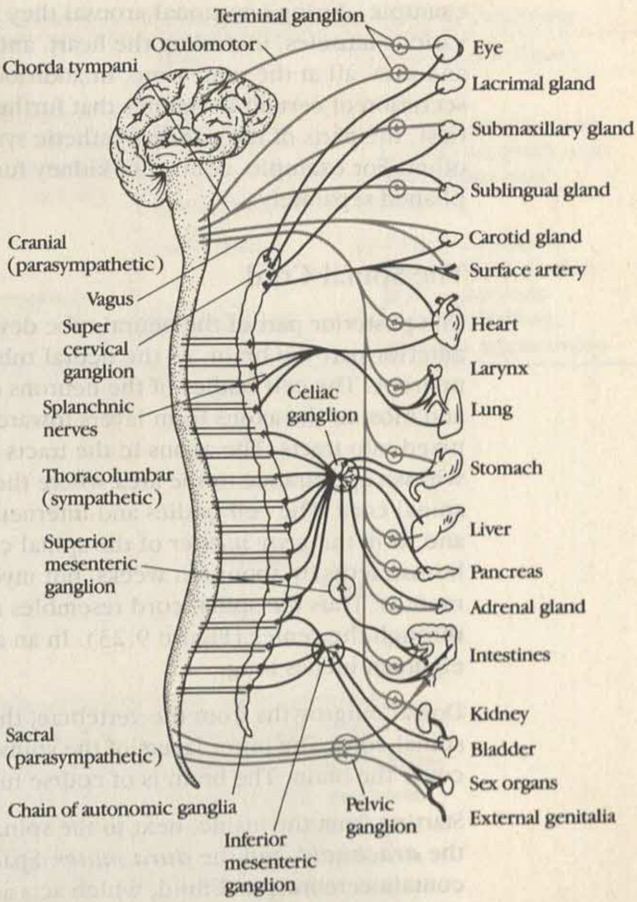


FIGURE 9.22 Autonomic nervous system. Parasympathetic fibers are indicated by colored lines, sympathetic by black lines. Note that most organs are innervated by both parasympathetic and sympathetic fibers.

The organs and glands in the body are innervated by the autonomic nervous system, and most of these are innervated by both sympathetic and parasympathetic nerves; thus they have dual innervation. Whatever the influence of one system on the organ, the other system frequently has an opposite effect. For example, stimuli from efferent sympathetic nerves to the heart increase the rate of heart contractions; those from the parasympathetic nerves decrease it. Activation of the sympathetic effectors reduces contractions of the smooth muscle in the intestinal walls; activation of the parasympathetic effectors increases them. This provides very precise control over the organs. Conflict between these opposing effects is avoided, because the activity of one system is depressed as the other is increased. Note that skeletal muscles do not have this dual innervation; they are supplied only with excitatory neurons.

In general, the sympathetic nervous system is more active during states of arousal and stress, while the parasympathetic system is more active during quiet, resting states. Also, the various parts of the sympathetic system tend to act together. For example, during emotional arousal they increase the heartbeat, dilate arteries of various muscles, including the heart, and constrict arteries of the digestive organs and skin, all at the same time. In addition, they promote perspiration and the secretion of certain hormones that further increase emotional excitement. In contrast, the parts of the parasympathetic system tend to work independently of each other. For example, control of kidney function and rate of heartbeat are accomplished separately.

The Spinal Cord

The posterior part of the neural tube develops to become the spinal cord, the anterior part the brain. As the neural tube grows, cells within it divide to form neurons. The cell bodies of the neurons come to lie nearer the center of the tube, and most of the axons form layers toward the outside, where they become organized into tracts. The axons in the tracts are myelinated. The myelin sheaths give a whitish appearance to the area where they are; this is the *white matter* of the spinal cord. The cell bodies and interneurons nearer the center are gray in color, and form the *gray matter* of the spinal cord. This arrangement is achieved in the human fetus by about ten weeks, but myelinization does not begin until about five months. Thus the spinal cord resembles a white cylinder with a gray mass running through the center (Figure 9.23). In an adult human the spinal cord is about eighteen inches long.

Dorsal outgrowths from the vertebrae, the neural arches, surround and protect the spinal cord. The outer layers of the spinal cord itself are the *meninges,* which also cover the brain. The brain is of course further protected by the skull.

Starting from the inside, next to the spinal cord, the meninges are the *pia mater,* the *arachnoid,* and the *dura mater.* Spaces between these protective membranes contain cerebrospinal fluid, which acts as a protective cushion. The function of the spinal cord is to receive impulses, which it integrates and coordinates and then transmits to the proper place, either in the CNS or in the PNS.

The Brain

By the time the neural groove closes over to form the neural tube, the anterior portion of the tube is already of greater diameter than the posterior portion.

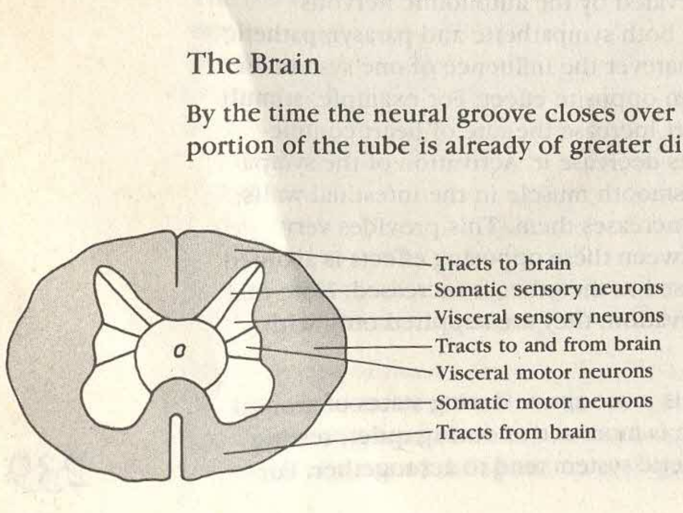


FIGURE 9.23 Cross-section of human spinal cord. Tracts (bundles of axons) carrying impulses from the spinal cord to the brain are concentrated dorsally. Tracts carrying impulses from the brain to the spinal cord are concentrated ventrally.

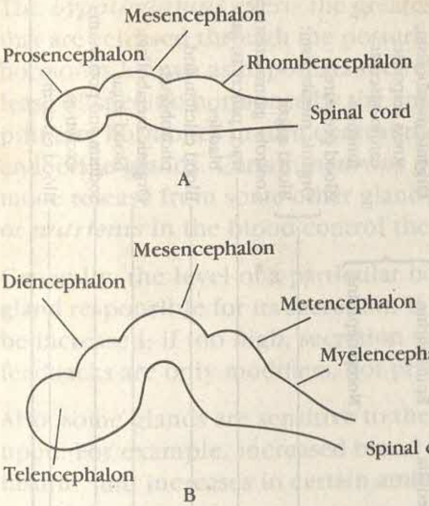


FIGURE 9.24 Two stages in the embryonic development of the chordate brain.
(A) About four weeks after fertilization.
(B) About five weeks after fertilization.

TABLE 9.1 Development of the Parts of the Brain

	Bulge	Part of Brain It Forms
Brainstem (Reticular formation in core)	Myelencephalon	Medulla
	Metencephalon	Pons; dorsal part becomes cerebellum, which is not part of brain stem
	Mesencephalon	Midbrain
Forebrain	Diencephalon	Epithalamus, thalamus, hypothalamus, pituitary gland, optic tracts
	Telencephalon	Cerebral hemispheres, amygdala, hippocampus

Shortly thereafter, at about four weeks in a human embryo, the anterior portion enlarges further and develops three bulges (Figure 9.24A). Some researchers believe this three-bulge stage is similar to the brain of the unknown ancestor of the vertebrates, and that these regions may have functioned in smell, vision, and taste and balance, respectively. During further growth the first and third bulges each constrict, so that two bulges develop where one was before, and at about five weeks the future brain has five bulges (Figure 9.24B). These are listed in Table 9.1 starting from the spinal cord and moving anteriorly, along with some of the parts of the brain they will form.

The brain attains its general structure in the human fetus at about twelve weeks, and it is thought that nearly all of the estimated 100 billion neurons of the brain have developed by about twenty weeks (Cowan, 1979; Hubel, 1979). However, myelinization is just beginning at twenty weeks, and in certain parts of the brain it may not be completed until adolescence (Tanner, 1978).

Supplement 2. The Functioning of the Endocrine System

Control of Hormone Secretion

There are three major or primary controls of hormone secretion. Although the immediate stimulus is usually different for each gland, all are subservient to these master controls. Table 9.2 summarizes the control of hormone secretion.

TABLE 9.2 Control of Some Hormone Secretions and Some Hormonal Functions

Control	Hormone	Gland Stimulated	Hormone	Gland Stimulated	Hormone	Some Functions
Hypothalamus	Antidiuretic	(via posterior pituitary)				Prevents water loss through kidneys.
	Oxytocin	(via posterior pituitary)				Milk secretion, uterine movement.
	Hypothalamic releasing factors	Anterior Pituitary	Adrenocorticotropic (ACTH)	Adrenal Cortex	Cortisol	Organic metabolism; stress response.
			Adrenocorticotropic (ACTH)	Adrenal Cortex	Androgens	Growth; sexual activity in females.
			Adrenocorticotropic (ACTH)	Adrenal Cortex	Estrogen	Androgen secretion in females?
			Gonadotropic (FSH & LH)*	Ovaries	Estrogen	Female primary and secondary sexual characteristics.
			Gonadotropic (LH)	Corpus Luteum	Progesterone	Prepares uterus for implanting of embryo (with estrogen).
			Gonadotropic (LH)	Testes	Testosterone	Male primary and secondary sexual characteristics.
			Gonadotropic (FSH)			Sperm production (jointly with testosterone).
			Growth (Somatotropin STH)			Growth; metabolism.
			Thyroid stimulating (TSH)	Thyroid	Thyroxine	Energy, metabolism; growth and development.
			Prolactin	Mammaries		Milk formation.
Autonomic Neurons				Adrenal Medulla	Epinephrine Norepinephrine	Organic metabolism, stress response; cardio-vascular function.
		Kidney	Renin			Blood pressure.
		Pancreas Pancreas	Insulin Glucagon			Organic metabolism; Blood sugar.
		Gastrointestinal Tract	Gastrin Secretin			Controls: gastrointestinal tract, pancreas; gall bladder.
Ions; nutrients		Parathyroid	Parathyroid			Blood calcium and phosphorus.
		Pancreas	Insulin Glucagon			Organic metabolism; blood sugar.
		Adrenal Cortex	Aldosterone			Sodium and potassium excretion.
		Thyroid	Calcitonin			Blood calcium.

* FSH = follicle stimulating hormone; LH = luteinizing hormone.

The *hypothalamus* exerts the greatest influence. It manufactures some hormones that are released through the posterior portion of the pituitary gland, and other hormones known as hypothalamic releasing factors, each of which controls the release of specific hormones by the anterior portion of the pituitary. The anterior pituitary hormones in turn control the release of hormones from several other endocrine glands. Certain *neurons of the autonomic nervous system* control hormone release from some other glands. Finally, the relative concentrations of *ions* or *nutrients* in the blood control the release of hormones from several glands.

Generally, the level of a particular hormone in the blood provides feedback to the gland responsible for its secretion. If the hormone level is too low, secretion will be increased; if too high, secretion will be reduced. Note, however, that such feedbacks are only modifiers, not primary controls.

Also, some glands are sensitive to the substances the hormones they secrete act upon. For example, increased blood sugar stimulates the pancreas to secrete insulin, and increases in certain amino acids stimulate the pituitary's secretion of growth hormone.

Growth and sexual development are two of the many areas in which hormones play key roles. We will discuss them briefly as examples of hormone activity.

Sex

This section deals mainly with differences between the two sexes, but first a few things they have in common should be pointed out:

1. The **gonads**—testes of males and ovaries of females—have a dual function in both sexes: producing gametes and hormones.
2. The anterior pituitary gonadotropic hormones—follicle-stimulating hormone (FSH), and luteinizing hormone (LH)—exert key (although different) influences in the two sexes.
3. The first of the sequence of events leading to puberty is a marked increase in secretion of the gonadotropic hormones.
4. **Androgens** and **estrogen** are produced in both sexes by the adrenal cortex; their different relative proportions are mainly responsible for the differences in secondary sexual characteristics. (**Primary sexual characteristics** are the reproductive organs; **secondary sexual characteristics** are other differences between the sexes, such as body hair and body contour.)
5. Secondary sexual characteristics do not develop until puberty.

Males Virtually all aspects of functioning of the male reproductive system are controlled by FSH and LH. Both are produced by the anterior pituitary gland, and both affect only the testes in males (Figure 9.25). Their secretion increases at puberty and continues at a steady rate throughout life.

FSH is essential for sperm production, which occurs in the testes, but must be supplemented in this by the action of testosterone. LH is responsible for testosterone production, which also occurs in the testes.

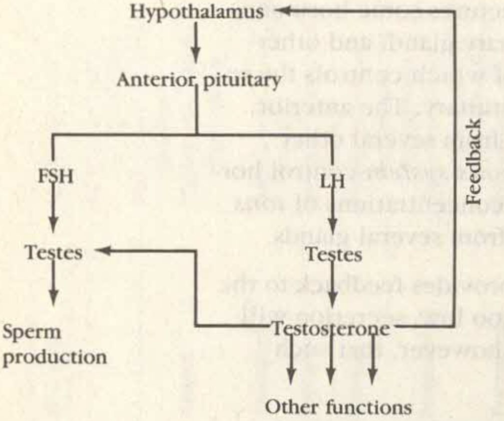


FIGURE 9.25 Activity of follicle stimulating hormone (FSH) and luteinizing hormone (LH) in human males.

Testosterone is the "male" hormone, the only hormone produced by the testes. It is one of a group of similar hormones called androgens, although it is much stronger than the others. These other, far weaker androgens are produced by the adrenal cortex, probably through stimulation of that organ by adrenocorticotropic hormone (ACTH), and produce effects similar to those of testosterone.

In addition to affecting sperm production, testosterone is also necessary for the initial development of male sexual behavior. Moreover, it is important for metabolism in general, and affects the development of secondary sexual characteristics such as body hair, deepening of the voice, and body contours (muscle mass, fat distribution, and relatively broad shoulders and narrow hips).

Estrogen is secreted in small amounts throughout life in males by the adrenal cortex, apparently under the influence of ACTH. Estrogen may be responsible for the breast enlargement that sometimes occurs in adolescent boys.

Females The adrenal cortex of females secretes both androgens and estrogen, as it does in males. Greater amounts of estrogen are secreted by the ovaries as they become functional. Androgens are important in general body growth, and in female sexual response. Estrogen is critical in sexual development, including that of secondary sexual characteristics, and probably contributes to general body growth during puberty. Thus the effects of estrogen in females is similar to that of testosterone in males, except for its lack of effect on sexual activity. Also, once the ovaries are functional the concentration of estrogen and some other hormones varies over a cycle of approximately twenty-eight days, as opposed to the steady supply of testosterone in males.

This twenty-eight day cycle is the *menstrual cycle.* On day one menstrual bleeding begins and the follicle cells begin to develop a new ovum. Bleeding lasts about three to five days. The ovum is released at about fourteen days. If fertilization does not occur, the cycle begins again about fourteen days later.

FSH and LH are critical to the development of the follicles of the ovaries, which produce the ova. The follicles are a second and major source of estrogen; as they develop, their estrogen secretion increases. The ovum goes through about two weeks of maturing, influenced by FSH, LH, and estrogen. Estrogen secretion increases rapidly during the second week of ovum development, and finally causes a burst of LH secretion which induces **ovulation** (release of the ovum). Ordinarily only one ovum is released in each menstrual cycle, and the two ovaries alternate in performing this function.

The ruptured follicle that has released the ovum is further stimulated by LH to develop into the *corpus luteum,* which secretes large amounts of estrogen and of another female hormone, **progesterone.** The large amount of estrogen provides negative feedback to the hypothalamus-pituitary, inhibiting production of FSH, while progesterone does the same for LH. The resulting lowered levels of FSH and LH effectively prevent other follicles from maturing their ova. The estrogen and progesterone also cause changes in the wall of the uterus, readying it for implantation of the fertilized egg.

If fertilization does not occur, the corpus luteum degenerates, the production of estrogen and progesterone by the corpus luteum ceases, and FSH and LH increase again. This stimulates a new follicle to develop, and also causes constriction of blood vessels in the uterus, which in turn causes disintegration and sloughing of the lining of the uterus, and bleeding. Now we are back to day one of the menstrual cycle.

If pregnancy occurs, high concentrations of estrogen and progesterone are maintained by the corpus luteum for the first three months of pregnancy. Maintenance of the corpus luteum is due at least in part to the hormone *chorionic gonadotropin* (CG), produced by the placenta; this hormone also strongly stimulates estrogen and progesterone secretion from the corpus luteum. CG becomes low by the end of the third month, but during the last six months the placenta itself secretes substantial amounts of estrogen and progesterone. High levels of estrogen and progesterone are essential all during pregnancy for maintenance of the specialized uterine structure and function.

Birth occurs with the aid of the hormone **oxytocin** from the posterior pituitary and **prostaglandin** produced in the pregnant uterus, both powerful stimulants of uterine muscle contraction. These hormones are also useful in inducing labor artificially.

Ovulation in humans may also be stimulated by sexual intercourse, especially if intercourse is infrequent. For example, the rate of conception for wives of military men home on leave is much greater than that for other women. Unfortunately, rape may have the same effect.

Growth

There are two periods of rapid growth in humans. One is from fertilization until about two years after birth. The other is during puberty. Growth can be most easily detected through increased cell division, increased manufacture and accumulation of proteins, and lengthening of the long bones. However, different body organs have different critical periods for growth. For example, brain growth may be stunted if there is severe malnutrition during infancy, but the reproductive organs would not suffer greatly at that time.

The capacity for normal growth is apparently genetically influenced, and if environmental factors are optimal a certain level of size and development will normally be achieved. But reaching this level depends on both external and internal factors. External factors include freedom from disease and excessive stress, and nutrition that is adequate both in amount and kind. The diet must include sufficient total calories, total protein, essential amino acids, essential fatty acids, vitamins, and minerals. Too much food can lead to obesity, which is not considered growth. The internal factors with which we are concerned are the hormones secreted by various endocrine glands, the functions they perform, and in some cases their interaction.

Growth hormone, technically called **somatotropic hormone (STH),** is secreted by the anterior pituitary and is necessary for normal growth. A deficiency retards growth, and excessive amounts result in above-normal growth. Excesses in young animals can produce giants; some individual humans with this problem have reached heights of nearly nine feet. Excesses in adults can result in acromegaly, a disfiguring disorder characterized by bone thickening and overgrowth of other organs, especially noticeable in the enlarged jaw and hands.

Insufficient secretion of growth hormone results in undersized animals. In humans the result is a midget, technically an ateolitic dwarf. Midgets have normal body proportions but are small; one, Lucia Zarate, is reported to have been only twenty inches tall. Other kinds of dwarfs all have abnormal proportions, but none of these are due to pituitary irregularities. An achondroplastic dwarf, for example, has normal adult head and body size but short limbs (Figure 9.26).

The growth promoting effects of STH are mainly due to its stimulation of cell division and protein manufacture. STH begins to appear in the human fetus at about eight weeks of age. It increases to a peak at twenty-five to thirty weeks, when levels are much higher than in children or adults.

Thyroxine is secreted by the thyroid gland as a result of stimulation by the thyroid-stimulating hormone (TSH) from the anterior pituitary gland. A deficiency of thyroxine results in retarded growth, and in infants can lead to mental retardation as well. Absence of this hormone significantly reduces amino acid absorption and the first step of protein production. However, an excess of thyroxine does not increase growth, though it does accelerate the breakdown of food material. Thyroxine appears in the fetus at between thirteen and eighteen weeks. Normal amounts are crucial for organ development, especially the development of the brain of the fetus and young child.

Insulin is essential for moving glucose (sugar) into cells, thus providing them with the material for energy, and for the production of fat and glycogen. Glycogen is the starch animals make for energy storage. Insulin also increases the absorption of amino acids by cells, and this, along with its effects on the final stages of

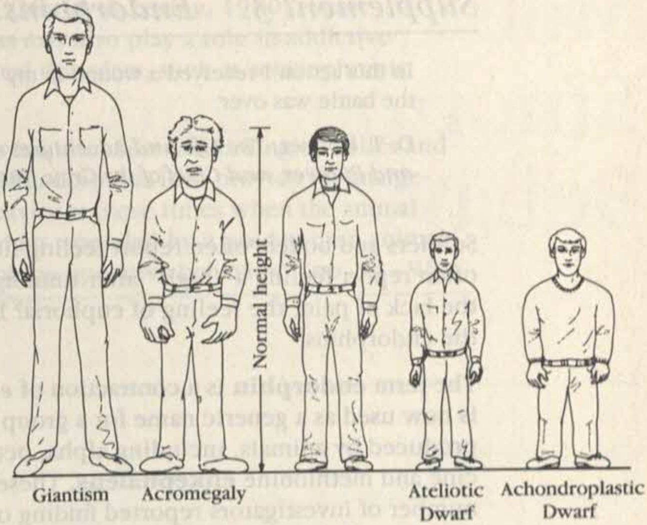


FIGURE 9.26 Giantism, acromegaly, and ateliotic dwarfism are results of anterior pituitary malfunctions. Achondroplastic dwarfism is shown for comparison.

protein manufacture, promotes protein production. Insulin deficit causes these processes to reverse.

Prolactin is a hormone secreted by the anterior pituitary. It promotes the growth of female breasts during adolescence, and the secretion of milk following pregnancy.

Androgens and estrogen are important in sexual development and functioning, described in the previous section. They also have profound effects on body growth in general. The androgens strongly stimulate protein production and bone growth. They also ultimately stop bone growth, when they have induced replacement of the last bit of cartilage by bone tissue. Androgens are responsible, at least in part, for the spurt of growth in both sexes during puberty. The increased muscle mass in males, as compared with females, is thought to be due to the presence of more androgens in males, in the form of the more powerful testosterone. In females there is a marked increase of the weaker androgens from the adrenal cortex during puberty.

Estrogen is secreted by the adrenal cortex in small amounts in both sexes, and by the ovaries in larger amounts beginning in adolescence. Estrogen profoundly affects the growth and development of primary and secondary female sex characteristics.

Supplement 3. Endorphins: Animal Opiates

> In this action I received a wound in my left side, although I did not perceive it until the battle was over.
>
> D. T. Bonner, *The Life and Adventures of James P. Beckwourth, Mountaineer, Scout, and Pioneer, and Chief of the Crow Nation of Indians* (1856).

Soldiers and boxers often report feeling little or no pain when hit, and runners often report feeling a "high" after running some distance. What is responsible for the lack of pain, the feeling of euphoria? It is the action of the body's own opiates, the endorphins.

The term **endorphin** is a contraction of *endogenous morphine-like substance.* It is now used as a generic name for a group of pain-killing, analgesic substances produced by animals, including alpha, beta, gamma, and delta endorphins and leucine and methionine **enkephalens.** These substances were discovered after a number of investigators reported finding opiate receptor sites in animal nervous tissues, including the human brain (Pert & Snyder, 1973). In order to combine with and activate these receptor sites, a substance must have specific chemical and physical qualities very similar to opium and its derivatives. But why should animal tissues have receptor sites specifically for a substance manufactured by ripening poppy plants?

Discovery of the opiate receptor sites led to speculation that animals may manufacture their own opiates, and a search for these substances began. By 1975 both of the enkephalens had been discovered, and isolation of the endorphins followed. Beta endorphin now appears to be the primary analgesic agent, with the enkephalens producing less powerful and shorter-term effects.

In one study, rats received painful intermittent electric shocks to the feet over a thirty-minute period, and their feet then were exposed to heat at a level that ordinarily would be quite painful. Some of the shocked animals were injected with naloxone, which blocks the effects of opiates, some were shocked but not injected, and some were neither shocked nor injected and used as controls. The shocked rats injected with naloxone showed ordinary sensitivity to the heat treatment, as did the controls. Shocked rats that were not injected showed reduced sensitivity to the heat treatment, suggesting that the physical stress of the electric shock resulted in release of endorphins that reduced pain sensitivity (Lewis, Cannon, & Liebeskind, 1980).

Other studies have shown an increase in endorphin levels in response to psychological stress. Students about to take important examinations were found to have increased endorphin levels in the blood. Rats that were electroshocked and then placed in the same chamber a week later but not shocked showed increases in brain endorphins (Pert, 1981).

Endorphins naturally elevate the pain threshold during pregnancy (Gintzler, 1980), presumably in preparation for childbirth. Endorphins are associated with obesity, and with stress-induced overeating (Morley & Levine, 1980). Some investigators have suggested that endorphins may also play a role in addictive behaviors, and in certain severe psychological disorders, such as schizophrenia (Coleman, Butcher, & Carson, 1984).

The adaptive significance of the endorphins is quite clear. According to Bolles and Fanselow (1982), "the major function of the endorphins is to provide for analgesia and the inhibition of pain-motivated behavior at those times when the animal should be defending itself. For example, when wounded by a predator, an animal should display defensive behavior and inhibit recuperative behavior" (pp. 94–95).

10

Motivation, Emotion, and Behavior

What Is Motivation?

Theories of Motivation

Homeostatic Motives

Other Motives

Emotion

Chapter Preview

Motivation can be defined as an internal state of *arousal,* resulting from some stimulus, that commonly leads to *behavior* that is directed toward a *goal.* Sometimes we are aware of what motivates ourselves or others, but sometimes we are not.

Two major theories of motivation are instinct theory and learning theory. *Instinct theory* became prominent in the late nineteenth century along with Darwin's works, and by the 1920s over eight hundred human instincts had been "discovered" to explain almost every human behavior. Psychoanalytic theory, established by Sigmund Freud, is another version of instinct theory. Freud proposed greatly reducing the number of instincts, and assigning those remaining to two major categories: Eros includes instincts aimed at preservation of life, especially sex; and Thanatos includes the death wish. The conflict of Eros and Thanatos results in aggression, Freud hypothesized.

Many psychologists rejected instinct theories and adopted an extreme version of *learning theory,* the idea that all human behavior can be explained by conditioning and learning. But experiments often suggested that unlearned motivational states influenced conditioning and learning. *Drive theory* was formulated to provide a means of relating motivation to learning. A major contribution of drive theory was that it took into account homeostasis, the body's efforts to maintain a stable internal environment. But saying there are drives does not really explain much more than saying there are instincts.

The homeostatic motives discussed in this chapter are hunger, thirst, and temperature regulation. Hunger is primarily under physiological control, but can be influenced by environmental cues. Physiologically, hunger may be controlled by excitatory and inhibitory centers in the hypothalamus.

Most adults maintain a fairly constant body weight, and it appears that the lateral hypothalamus (LH) and ventromedial hypothalamus (VMH) are involved in this long-term control also. It is believed each individual has a "setpoint" for the body weight that is maintained by the individual's pattern of eating and satiety, and that in obese people this setpoint is at a higher than normal level.

Thirst is affected by water deficiency or by increased salt concentration in the body liquids, or both. We normally replenish water in the body by drinking, and water also can be recovered from the kidneys. Thirst is remedied when there is sufficient water in the bloodstream, which is detected by another area in the hypothalamus.

Temperature control in warm-blooded animals — birds and mammals — also seems to be centered in the hypothalamus. Physiological mechanisms that promote cooling in humans include dilation of skin capillaries, increased respiration, and perspiration. These can be supplemented by behaviors such as finding shade, getting wet, and fanning. Physiological mechanisms that promote warming include increased metabolism, constriction of skin capillaries, and shivering. Humans can also add clothing, build a fire, and increase physical activity.

The homeostatic motives clearly have a strong genetic component. The other motives we discuss — curiosity and sensory stimulation, sex, and social motives — also are genetically influenced, but learning plays a much greater role.

Curiosity and sensory stimulation are logical requirements for organisms for which information about the environment has obvious survival value, for which sensory stimulation is essential for normal development, and for which learning is important for adapting to the physical and social environment.

Sexual behavior and reproduction are practically inseparable in animals other than humans. For humans sex also provides pleasure. Reports by Kinsey and by Masters and Johnson have been quite useful in understanding human sexual behavior. A number of social motives have been suggested. Most of them can be interpreted as ways of achieving biological success.

The topic of emotion is closely related to that of motivation. Emotions consist of internal states of physiological arousal that can intensify or disorganize behavior. Research suggests that the facial expressions of certain human emotions are used and interpreted in the same way by people of different cultures.

Various theories have been proposed to explain how emotion works. These include the James-Lange theory, the Cannon-Bard theory, the Schachter-Singer cognitive theory, and the opponent-process theory. Developmental studies indicate that elements of emotion are influenced genetically as well as by certain kinds of pre- and postnatal environmental factors.

What Is Motivation?

We often speak of being motivated to do something, or of having a problem in getting motivated. And we have all had the experience of feeling highly motivated—of feeling determined to accomplish some end, perhaps even excited about it, whether the goal was escaping pain or obtaining food or getting a date with that special person. But just what do we mean by motivation?

We already have some clues as to what motivation involves. First there is *arousal,* which involves a feeling of determination or some degree of excitement, and this is ordinarily directed toward some *goal.* But if the goal is to be realized, some *behavior* must be directed toward attaining that goal.

This child appears to be motivated.

With these ideas in mind, we could define motivation as an internal state of arousal that commonly results in behavior that is directed toward some goal. But our definition would be more complete, and more satisfying, if we could include something about what *causes* motivation in the first place.

Identifying the causes of motivation may be difficult in a particular situation. However, we can generalize, and say that motivations result from stimuli. But what sorts of stimuli? One way of classifying stimuli is according to whether they are external or internal. Some obvious external stimuli that motivate behavior are the sight and smell of food, cold temperatures, or even news about an opportunity or a danger. Internal stimuli include such things as a feeling of hunger without the presence of food, and mental events such as the realization that a particular goal can be achieved by some course of action. And of course combinations of external and internal stimuli can also lead to motivation.

Now that we have identified some possible causes of motivation, we can rephrase our definition to make it more complete. **Motivation** is an *internal state of arousal,* resulting from *some stimulus,* that commonly leads to *behavior* that is *directed toward a goal.*

Explaining what motivates an individual to perform a particular behavior may be difficult. Often we are aware of what motivates our own behavior, but sometimes we may not be. We usually must *infer* the motivations of other humans and other animals by observing their behavior. To the extent that our inferences are correct, we can *explain* some of the reasons for behavior, and may be able to *predict* future behavior.

Theories of Motivation

Instinct Theories

The idea that instincts are motivators of behavior in animals has a long history, but it was Charles Darwin's *On the Origin of Species by Means of Natural Selection* (1859) and especially *The Descent of Man* (1871) that brought into prominence the idea that humans have instincts. As Darwin's other ideas became rapidly and widely accepted, so did this one, and American psychologists and other scientists gave human instincts increasing consideration. The prominent American psychologist William MacDougall published a list of instincts in 1908, and other psychologists proposed additional instincts. By the mid-1920s American psychologists had proposed over eight hundred human instincts. Once the bandwagon got rolling, an instinct was found for most any behavior.

It should be pointed out that Darwin did *not* propose that instincts *force* us to behave in certain ways, or without rational control; neither did he argue that instinctive behavior cannot be modified. Nevertheless, many American psychologists held these views.

European psychologists did not assume the extreme position taken by American psychologists regarding instincts. European psychologists assimilated Darwin's ideas and simply expanded their models for human behavior, rather than changing models. Thus they allowed for genetic influence and proceeded without much disruption. As a result of not trying to explain virtually all human behavior by instincts, they also avoided the pendulum swing to the other extreme that dominated American psychology after the bandwagon broke down. When the instinct theories fell into disfavor, many American psychologists adopted the idea that human behavior is learned, with negligible genetic influence. Since there were also some American psychologists who thought more in the European mode, the nature-versus-nurture arguments persisted.

Psychoanalytic Theory Sigmund Freud tried to clarify the situation by greatly reducing the number of instincts, and assigning those remaining to one of two major categories. One he called **Eros,** which included life-perpetuating and life-sustaining instincts. Sex was paramount in this category, which also included survival and the associated instincts to obtain food, water, and other necessities.

The second of Freud's instinct categories he called **Thanatos,** which included the death wish and which we discuss in Chapter 16. Freud envisioned Eros and Thanatos as conflicting forces, and believed their interaction resulted in turning the death wish toward others, in the form of aggression. But social standards did not allow the free expression of sexual and aggressive instincts. Freud believed these instincts were often *repressed,* in part because of these societal standards, but remained in the unconscious as *unconscious motivations* that were expressed in different and often apparently unrelated ways.

Learning Theory

Faced with the explosion of the number of "instincts" and the difficulty of testing Freud's ideas experimentally, many psychologists followed the lead of John B. Watson (1913), who rejected the idea that instincts and the unconscious should be considered part of psychology. They proposed that human behavior could be explained entirely by conditioning and learning, and that these phenomena were best understood as overt responses to external stimuli. According to Watson, it was unnecessary, even unscientific, to suggest that *internal* conditions motivated organisms to do what they do.

Drive Theory Not all psychologists who supported the major tenets of learning theory subscribed to Watson's extreme position, and some attempted to formulate theories to account for the role of motivation in learning and behavior, without resorting to instinctual explanations.

Woodworth (1918) coined the term **drive** to describe the motivating force for satisfying needs. Later, Hull (1943) and others proposed that drives are aroused by stimuli that disrupt **homeostasis,** the tendency of an organism to maintain a relatively stable internal environment, including stable temperature, heart rate, water level, and blood sugar. Drive functions to energize behavior, or activate the organism, in order to restore homeostasis. Thus, lowered blood sugar results in a hunger drive which motivates the organism to find and consume food. Eating replenishes necessary sugars, thereby restoring homeostasis and reducing drive.

Learning takes many forms.

According to Hull, drives can be unlearned—*primary* drives—or learned—*secondary* drives. Primary drives are based on various biological needs, such as the need for food and water. Secondary drives are based on acquired needs, such as the need for status, achievement, security, and power.

Experimental evidence was not always kind to drive-reduction theory. Test animals do not always behave as they would be expected to if their goal were to reduce tension. Indeed, humans often seek out dangerous situations—roller coasters, mountain climbing, football—that increase tension.

Although drive theory has difficulties when faced with these tendencies to perform activities that induce arousal, it is useful for explaining some other kinds of motivations. At least some primary drives might be explained by the action of physiological homeostatic mechanisms. But more recent research indicates that there is more to motivation than drive-reduction. In some cases it appears that organisms seek an *optimal* level of arousal, as opposed to a *reduced* level. And in other instances, an individual's *goals* and *cognitions* seem to be important motivators of behavior, independent of drive states (Hoyenga & Hoyenga, 1984).

Drive, Motive, and Instinct

Perhaps it has occurred to you that while saying a behavior is motivated by an instinct is not a satisfying explanation, neither is saying that, instead, a behavior is motivated by a drive or a need. Relabeling is not the same as explaining. None of these terms explains very much, and in fact even the term *motive* is at risk. Just as an instinct was found for most every behavior in earlier times, more recently the number of motives has been increasing in the psychology literature—power motive, acquisition motive, possession motive, social contact motive, achievement motive, curiosity motive, motive toward self-actualization. Saying we have motives may not explain very much either.

Some of the explanatory difficulty associated with the concepts of instinct and motive arises from lack of agreement on definitions of each term and from failure to distinguish between the two concepts in a precise manner. Instincts are often equated solely with innately governed behavior, and motives solely with learned behavior. Yet we see many cases where so-called instincts can be modified by experience through learning, and cases where motives such as hunger and thirst appear to have an innate basis.

Epstein (1982) has attempted to provide a means of distinguishing between the two concepts. Epstein argues that motives, as well as instincts, *can* have an innate basis, and both *can* be influenced by learning. However, he proposes three major ways in which motives differ from instincts. First, *different individuals can learn different ways of satisfying a motive,* whereas instinctual behaviors tend to take the same form from individual to individual. For example, a hungry stray cat may wander through alleys preying on mice, while a house cat may only have to show up and purr to secure a meal. Both cats experience hunger as their genetic programming "responds" to an environmental condition—food deprivation. But because each cat has learned a different method of obtaining food, Epstein would consider their food-getting behavior in this instance to be *motivated,* not instinctual. When stalking a bird, however, the two cats will display very similar behaviors, despite their different backgrounds; and thus their bird-stalking behavior, according to Epstein's criteria, would *not* be considered motivated behavior.

The second distinctive feature of motivated behavior, according to Epstein, is that it involves *expectancies.* Thus, there is a cognitive component to motivated behavior—anticipation of the outcome of some goal-directed activity—that is missing or present to a lesser degree in instinctual behavior.

Epstein's third difference between motivated and instinctual behavior involves the presence of *emotion.* Motivated behavior is more likely to be accompanied by expressions of emotion than is instinctual behavior.

Thus in Epstein's view motivated behavior, though it *may* result from innate factors, is more flexible, more cognitive, and perhaps more emotional than is instinctual behavior. Now let us consider yet another scenario. It *could* be argued that *all* motives arise because of innate factors. Consider the possibility that instincts, motives, needs, drives, and even learning all occur because organisms are genetically programmed to perform behaviors that contribute to their biological success. According to this view instincts and motives differ only in the flexibility, or "openness," of their underlying neural circuitry. Instincts would be triggered by neural circuits that have relatively few connections with other circuits—imagine a limited series of reflex arcs (see Chapter 9). The neural circuitry responsible for motives would have considerably more connections with other circuits, thus permitting a greater degree of modification of the neural impulses and, therefore, of the resulting goal-directed behavior. The more open the neural circuit to other inputs, the more likely it would be that learning would play a significant role in directing behavior. The factor determining the openness of the relevant neural circuitry is genetic programming as it interacts with the organism's environment during development. Thus, like instincts, motives such as hunger and thirst are based on genetically programmed physiological mechanisms. However, we *learn* when and how to satisfy hunger. Other motives, such as achievement, depend much more heavily upon learning, but fulfilling these motives often promotes our biological success also.

Homeostatic Motives

Hunger

The fallacy of the nature-versus-nurture argument is perhaps never more clear than in the case of hunger. While hunger is primarily under physiological control (nature), our feeling of hunger and our eating are also influenced by learned environmental cues (nurture). In other words, external environmental factors as well as genetically programmed physiological reactions can serve as stimuli for eating; as is so often apparent, *both* nature and nurture are involved.

For example, the sight, smell, or mention of food can stimulate a desire to eat even though we have recently had a good meal and are not feeling hungry, if the food in question is a favorite dessert. We also may begin to feel hungry upon noticing that it is our usual mealtime. And we may feel hungrier and eat more on social occasions, when a meal is taken with friends or family, especially at times of celebration.

The ultimate function of hunger is to maintain nutritional homeostasis—to balance energy supply with energy expenditure—and to maintain a constant body weight. Strange as it may seem, this appears to be as true of obese people as it is of those of normal weight.

Hunger Control It has long been thought that the control of hunger and satiety, and thus the primary control of eating, is centered in the hypothalamus. This seems logical because, as you will recall from Chapter 9, the hypothalamus is a major control site for many physiological activities. A good deal of research has indicated that stimulation or destruction of cells in certain regions of the hypothalamus can have profound effects on eating. While some objections have been raised to the conclusion that control of hunger and satiety is centered in the hypothalamus, none has garnered much research support. However, even if these objections are verified, the fact remains that primary controls appear to be in the brain, and can be manipulated by treatment of the hypothalamus.

The classical theory of hypothalamic control holds that there are two centers in the hypothalamus that control hunger, one that acts as an "on" switch for feeding, the other as an "off" switch. A region in the side of the hypothalamus, the **lateral hypothalamus (LH),** has been called the *excitatory* center. When the LH is stimulated with a weak electrical current, satiated test animals will eat, often voraciously; the electrical stimulation apparently stimulates the "on" switch. However, when the LH is destroyed the animal does not feed at all, and will die of starvation unless fed artificially, usually intravenously.

Another region, the **ventromedial hypothalamus (VMH),** in the lower middle of the hypothalamus, has been called the *inhibitory* or *satiety* center. Mild electrical stimulation of the VMH is followed by less feeding than normal in an animal that has been fasting and therefore is presumably hungry. With stronger electrical stimulation, feeding ceases entirely. Destruction of the VMH of a satiated animal results in feeding, often voraciously.

The above results suggest the LH is the "on" switch for feeding and the VMH is the "off" switch, and this may well be the best and simplest explanation. LH turns hunger on, VMH turns it off, each at appropriate times. Some researchers have suggested that the LH and VMH act as antagonists, each either inhibiting or overriding the other according to the particular situation.

But if the LH and VMH are in fact "on" and "off" centers, or if they inhibit or override each other, what is it that causes them to go into action? A number of external and internal factors have been identified that can affect hunger and feeding.

External Cues Learning probably plays a major role in the effectiveness of most of the environmental stimuli that tend to induce hunger or eating. A tasty dessert would not give either visual or olfactory cues for hunger to a person who has not learned to associate its appearance or odor with its flavor. Having learned these associations, however, we may feel like eating the dessert even though we are not hungry. It is probable that most food preferences are learned, and the same may be true of many food aversions. However, sweetness is desirable to humans of all ages and to many other mammals, just as bitterness is generally undesirable. It is also possible that there are individual differences in sensitivities to tastes and smells that are relatively independent of learning.

This child is probably no longer hungry.

On the other hand, we may find foods aversive for various learned reasons. Many of us have had the experience of becoming ill after eating a perfectly suitable food, particularly if we overindulged. But even if the illness was due to other causes we may subsequently find that food aversive, even nauseating. Some people find the mere suggestion of eating beef brains aversive, and for many the eating confirms these feelings, not because of the flavor but because of the mushy texture brains can have when not properly prepared. In Europe and the

Middle East, however, brains are considered a delicacy.

Other external cues are at work when we suddenly feel hungry as soon as we notice it is our normal mealtime, or when we eat more when with certain people. A variety of foods with a variety of flavors commonly induces us to eat more, and we may be more inclined to eat foods we are used to than those that are unfamiliar. Finally, humans tend to eat less when environmental temperatures are warm, more when they are cool.

Internal Cues Perhaps the most familiar internal signal that we have had enough to eat is a full stomach. Likewise, perhaps the most familiar internal signal that we are hungry is the onset of stomach contractions. In many individuals stomach contractions are followed by feelings of weakness, light-headedness, or even dizziness if food is not eaten. These symptoms often accompany a low level of blood sugar (glucose).

The glucose level in the blood supply to the brain is kept rather constant even when the rest of the body is experiencing a shortage. Even so, we know the hypothalamus *can* respond to blood glucose (Anand, Sharma, & Dua, 1964; Miselis & Epstein, 1970), and it probably does if blood glucose becomes low enough. However, the liver is of major importance in food metabolism, and is therefore a likely place to look for hunger control. When Russek (1971), in an experiment using dogs, injected glucose into the blood vessels supplying the liver, the dogs stopped eating. If the hypothalamus is a center for hunger control, perhaps it receives information from the liver. Russek's results suggest that, although digestion is slow, if we are eating slowly we may feel satisfied when the blood sugar level is recovering. Blood glucose in *excess* of present need is converted to glycogen for energy storage. Glycogen can then be reconverted to glucose as *needed.* It is possible that *hunger* may be induced when this reconversion is detected, perhaps by the liver.

Long-Term Control Most adult animals and many adult humans maintain a fairly constant body weight over long periods of time. In addition to the short-term controls already described, the LH and VMH also appear to function in this long-term control.

We have already described how test animals such as rats and cats whose LHs are destroyed refuse to feed, even if food is placed in their mouths; they die if not fed artificially. However, after a time the test animals start eating again in limited amounts if offered certain wet and apparently tempting foods, such as chocolate milk, but still refuse ordinary food and will not eat enough to sustain life. Still later the animals eat enough of the wet and tempting food to stay alive, but continue to refuse ordinary food. Finally, they begin taking ordinary food, and gradually increase this sufficiently to remain healthy without supplementary artificial feeding (Epstein & Teitelbaum, 1962). It appears that other parts of the brain slowly take over the feeding function of the LH when it has been destroyed. However, although the animals recover, their body weight is maintained at a much lower level than previously. Interestingly, monkeys with LH lesions refuse to eat unless food is placed in their mouths. The neocortex is more highly developed in monkeys than in the other mammals tested, and it may be more involved in feeding. Also, humans with certain hypothalamic lesions caused by tumors or other factors experience greatly reduced appetites and suffer substantial loss of weight; this condition is known as Froelich's syndrome.

Destruction of the VMH has an opposite effect, as might be expected. Test animals usually eat voraciously, consuming much more food than normal, until their body weight reaches some higher level. For rats this is between two and three times normal weight. However, a point is reached at which feeding is reduced, and body weight is then maintained at the higher level. If force-fed until extremely obese, and then taken off force-feeding, these animals return to and maintain the previous obese levels they rose to after the VMH was destroyed. Although these animals eat more than normal amounts, they tend to be finicky eaters. They show a strong preference for soft and tasty foods, and will overeat more if their food is sweetened, but they will not work as hard for food as hungry normal rats will. On the other hand, obese rats do not increase consumption if their food is diluted with as much as 25 percent cellulose, though normal animals compensate by eating more. Thus it appears that external factors, probably taste in particular, are more important in animals whose VMH has been destroyed.

Finally, if both the LH and VMH are lesioned an equivalent amount, animals continue eating normal quantities and maintain normal body weight. All these results indicate that long-term weight control is influenced by the hypothalamus. You should note, however, that there is some question as to whether the LH and the VMH are in fact feeding and satiety "centers," as the classic lesion and stimulation studies seem to indicate. More recent evidence suggests the possibility that LH lesions may impair eating because of effects on brain mechanisms near the hypothalamus that are *not* specific to food intake. Other studies indicate that overeating and obesity related to VMH lesions may occur for reasons other than interference with a satiety center. For example, such lesions may affect metabolism so that conversion of glucose into fat is increased, and breakdown and metabolism of fats is reduced. Although the LH and the VMH *act* as if they were start and stop centers for eating, the precise physiological mechanisms involved may be much more complex (Carlson, 1981).

Obesity in Humans Schachter (1971) believed that eating by obese people is more readily influenced by external cues than it is for nonobese individuals. According to Schachter, obese people are influenced much more by the sight, smell, taste, or mention of food, and eat much more of good-tasting foods and much less of other foods than nonobese people do. They also eat more when food is easy to get, and less when it is harder to get. Parallels with VHM-lesioned rats are striking. However, recent evidence suggests that *nonobese* persons show individual differences in responding to external food cues, with some being more susceptible to such cues than others (Rodin, 1981). Thus Schachter's hypothesis may not be a sufficient explanation of overeating and obesity.

One characteristic that clearly distinguishes the obese from the nonobese is the greater number of fat cells present in the obese. The number of fat cells is apparently determined early in life, perhaps partly by the amount of food eaten, but probably heredity is the main determinant. Overeating increases the size, and storage capacity, of the fat cells, while starvation decreases their size; the number of fat cells is not affected.

The fact that the body weight of most adults does not vary much is primarily because physiological mechanisms tend to balance energy intake and output in normally active people. What seems to be operating here is called a **setpoint.** Setpoints appear to operate in obese people but at a higher than normal level.

Destruction of parts of the hypothalamus, as discussed above, seems to alter the setpoint. Certain drugs, such as amphetamines and nicotine, seem to lower the setpoint, but it returns to its former level when the drugs are withdrawn. Regular exercise also appears to lower the setpoint, and is both healthier and more effective than drugs. In addition, Thomas and Mayer (1973) found that in individuals who are very inactive physically the setpoint may rise and obesity result, even in formerly nonobese people.

Unfortunately for the obese, homeostatic mechanisms in the body seem precisely tuned to maintain an individual's setpoint. The body tends to slow down its metabolism under conditions of food deprivation, such as a weight-loss diet, ensuring that body weight is maintained. Moreover, the magnitude of this metabolic adjustment increases with increasing food deprivation (Wooley, Wooley, & Dyrenforth, 1979). Therefore dieting makes it increasingly difficult to take the pounds off and keep them off. This is basically a very adaptive biological response, of course. Natural selection favored those early humans best equipped to survive under conditions they were likely to encounter. Our hunter-gatherer ancestors undoubtedly faced periods of food shortage from time to time. A homeostatic mechanism for reducing energy requirements would have had obvious value under those conditions.

Thirst

Just what is it that causes us to feel thirsty? If you guess it is due to a water deficiency, you are correct. But what else? Maybe you recall having eaten some salty food, such as ham, and later feeling especially thirsty and consuming unusual amounts of water. So how about increased salt concentration as a cause of thirst? Right again.

Just as eating supplies the body with fuel and nutrients, drinking supplies water for metabolism and the replenishment of body liquids lost through evaporation, urination, or bleeding. We also can *conserve* water in the body by recovering it from the kidneys. If the body has plenty of water, none is recovered from the kidneys and the urine is relatively dilute. But if the body is experiencing a shortage of water, **antidiuretic hormone (ADH)** is released, with the result that water is recovered from the kidneys and the urine is more concentrated.

Generally we drink when we are thirsty, and one signal to stop drinking is thought to come from distension of the stomach. If we are quite thirsty, we may continue to drink until sufficient water has been absorbed into the bloodstream.

In an attempt to determine what triggers signals for drinking or not drinking, Adolph (1941) inserted tubes into the esophagi of dogs so that water they drank could not reach their stomachs. The dogs drank their usual amount, and after several minutes drank the same amount again, and then again; increasing dehydration caused increasing amounts of water to be consumed. Distension of the stomach did not occur, nor did water reach the tissues.

Adolph also inserted tubes into dogs' stomachs so that they could be given water without drinking it. When thirsty dogs were given water through the tube, they drank if allowed immediate access to water. But the desire to drink waned rather rapidly, and if the dogs were not given access to water until twenty minutes after receiving water through the tube they did not drink at all. In this case the stomach was distended, but satiety did not occur until there had been time for water to be absorbed and reach the tissues. Thus in Adolph's experiments with thirsty dogs, neither the act of drinking nor distension of the stomach produced satiety.

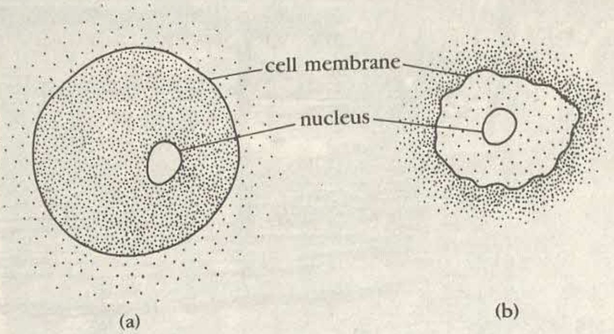
Body liquids occur intracellularly (within cells) and extracellularly. Extracellular water occurs between and around body cells, and in the blood. For convenience, we will refer to the water between and around cells as *extracellular,* and the water in the blood as *blood plasma.* These liquids contain many dissolved substances, including about 0.9 percent salts. This is approximately the concentration of salts in sea water, and is believed to reflect the evolutionary origin of life in ocean waters.

Drinking water is the usual way of replenishing body liquid and supplying water for metabolic processes.

A loss of extracellular water results in increased salt concentration, which causes a loss of intracellular water due to osmosis (Figure 10.1). The increased salt concentration is detected by the supraoptic nuclei, which are located just above the posterior pituitary gland, in the hypothalamus. Electrical activity in the supraoptic nuclei triggers the posterior pituitary to release antidiuretic hormone, which causes thirst, and causes blood vessels in the kidney to become permeable and absorb water from the urine. Water absorbed from the urine helps dilute the body liquids so that the salt concentration is reduced. Of course by drinking water we accomplish the same thing.

One way of losing body water that does not often come to mind is through bleeding. Loss of blood reduces the liq-

FIGURE 10.1 (a) Normally, the concentration of salt is somewhat greater inside a cell than outside; water then tends to be absorbed by the cell. (b) If extracellular water is lost, the concentration of salt becomes greater outside the cell, and the cell loses water.



uid content of the body, which is why people who suffer substantial blood loss are thirsty. When blood is lost, the body loses blood plasma, and salts are lost along with the liquid. A similar effect is produced by rapid and excessive perspiration. The resulting reduction of body liquid reduces the amount of blood reaching the kidneys, which respond by secreting the hormone **renin.** Renin enters the blood and causes the conversion of the normal blood component angiotensinogen to the hormone **angiotensin.** Angiotensin causes thirst, and stimulates the adrenal cortex to release the hormone **aldosterone,** which acts on blood vessels in the kidney to make them more permeable to salts. In this way salts are recovered from the urine also.

Temperature Regulation

Most animals are cold-blooded. Generally this is taken to mean that they assume the temperature of their external environment. Many of them do, but most insects and most vertebrates other than fish exercise substantial temperature control by their behavior. They move into the sun or find shade, and produce heat by muscle activity. They also retreat to burrows or other protected places when the air is too warm or too cool, and at this time may assume the environmental temperature. As body temperature goes up or down, physiological activity increases or decreases.

Only birds and mammals are warm-blooded, and maintain a rather constant body temperature. This is achieved by homeostatic physiological mechanisms that are often supplemented by temperature-regulating behaviors similar to those of cold-blooded animals.

Temperature control, like hunger and thirst, seems to be centered in the hypothalamus. Cells in the anterior region of the hypothalamus apparently act as a thermostat, receiving information from skin receptors and the blood and stimulating cells located posteriorly in the hypothalamus to regulate temperature (Myers, 1969).

Cooling in humans is assisted by dilation of capillaries in the skin ("flushing"), which allows heat loss from the blood; increased respiration; and perspiration, which allows heat loss by evaporation of water. These physiological mechanisms are often supplemented by behaviors such as finding shade, getting wet, going indoors, consuming cold drinks, fanning, and remaining as inactive as possible.

Warming in humans is accomplished by such mechanisms as secretion of thyroxine by the thyroid gland, which increases metabolic activity, producing heat; constriction of skin capillaries, avoiding heat loss from the blood; and shivering, which produces heat from

A dip in the lake can be a pleasant means of reducing body temperature.

muscle contractions. We also get goose pimples, or gooseflesh, the erection of the skin's papillae. In other animals this mechanism raises fur or feathers to create dead air space and provide insulation, but of course it doesn't help us humans. Voluntary behaviors to increase warmth include adding clothing, building a fire, finding or making shelter, turning up the thermostat, and increasing physical activity.

Other Motives

The homeostatic motives clearly have a strong genetic component. The motives discussed next are also genetically influenced, but in these motives learning plays an increasing role.

Curiosity and Sensory Stimulation

Investigation and the manipulation of objects by monkeys is so well known that *to monkey with* means to tamper with or to manipulate in an exploratory fashion, and *to monkey around* means to fool around with something, or perhaps just to do this or that. Young monkeys romp, wrestle, run, tease, and, as do adults, they investigate and manipulate objects. Monkeys will "monkey with" hasps, door hooks, knobs, or almost any object, particularly if it is novel; when the novelty wears off, they do something else. It seems obvious that they seek sensory stimulation, that they are curious about their environment, and that exploring the environment provides stimulation. This is quite understandable, even expected, from a natural selection perspective, since information about the environment has obvious survival value, and sensory stimulation is essential for normal development (see Chapter 6). In addition, curiosity might be expected to be of special importance for species that depend heavily on learning as a means of adapting to their physical and social environments.

While a knowledge of environmental conditions might not seem as valuable for humans as for wild animals, in fact it is. Consider trappers or Eskimos or prospectors in the desert—people who tend to live more like our ancestors did. They must know where water or game can be found, what predators are in the area and where they are likely to be located and when they are likely to be encountered, and how and where to escape environmental extremes. This applies also to the residents of cities. It pays for us to know about our environment, including how to find our way home, or, in the social environment, how to talk to the boss.

But in addition to exploring and monkeying around with objects, humans have devised many other means of sensory stimulation: skiing, mountain climbing, vacations, trips, pets, magazines, books, radio, television, plays,

Curiosity can increase familiarity with one's environment.

Cabin fever, familiar to those who have their activities restricted by long periods of severe weather, might be considered a form of sensory deprivation syndrome.

concerts, tasty foods, conversation, games, sports, and no doubt you can think of many others. We don't often continue any one activity for more than a few hours. We tend to keep changing to something different, seeking change or novelty, reading different books, climbing different mountains.

No doubt you have heard of "cabin fever"; perhaps you've even experienced it. Cabin fever, *sensory-deprivation syndrome,* is experienced by nearly anyone who is restricted for long periods by severe weather, especially very cold weather. The lack of variety of sensory stimulation creates intense boredom. Similar feelings are often reported by the elderly and the handicapped, and by people recovering from medical problems, especially if they must stay in bed.

An interesting experiment on sensory deprivation was conducted by Bexton, Heron, and Scott (1954). They paid male college students the then handsome sum of twenty dollars a day to lie on a bed in a room that was nearly soundproof, with air conditioner and exhaust fan motors masking outside noise. The subjects wore loose pajamas, tubes enclosed their hands and extended to the elbows, and their ears were shielded by a U-shaped pillow. In addition, they wore translucent eye coverings so that they could detect light only. The subjects were given short breaks when desired for eating, drinking, and using the bathroom. Thus for most of the time they were deprived of most sensory experience, including social stimulation. Most of the students quit after only two or three days, in spite of the attractive monetary rewards. They reported experiencing an inability to concentrate or think clearly, visual hallucinations, and feelings of disorientation in regard to both time and space.

We saw in Chapter 9 on physiology that sensory information from touch, taste, visual, and auditory receptors is received by the dorsal thalamus and passed to the cerebrum. This activates sensory areas of the cerebral cortex, but the cerebrum is also stimulated in another way. Sensory nerves also affect the reticular formation, which arouses the cerebral cortex with diffuse neural impulses and thus helps prepare it to respond. Lack of cerebral cortex stimulation may be a physiological explanation of boredom.

It is apparent that different individuals seek different levels of sensory stimulation and exhibit different levels of curiosity. Eysenck (1967) maintains that this is because people differ in the way the reticular system functions; in other words, they have different levels of arousal. He suggests that introverts have a low threshold for stimulation of the reticular formation, and thus require only low levels of stimulation, while extroverts need high levels of stimulation, such as constant companionship and noisy or exciting activities.

Sex

Sexual behavior and reproduction are largely inseparable in animals other than humans. Even other mammals, including primates, indulge in sexual behavior only at times when females can become pregnant, just prior to and during ovulation. At that time the females secrete a **pheromone** that attracts and arouses males. Females are not sexually receptive at other times, nor do the males show much interest. But for humans the situation is quite different. Although a major function of sex is reproduction, sex is also quite pleasurable for humans. The vast majority of human copulations are indulged in for sensory gratification rather than reproduction.

One evolutionary question that has attracted much interest is why human females differ from females of other species in being sexually receptive, or at least sexually capable, on a more or less continuous basis. This permits sexual pleasure for both sexes at almost any time, and perhaps the explanation is as simple as that. Once our ancient male ancestors no longer *required* the smell of a pheromone to become aroused, females who were interested in sexual activity at times other than during ovulation could have attracted males more readily. In doing so they may have gained a more dependable food supply and more extended protection for themselves and their children, and thus contributed more surviving offspring, and genes, to subsequent generations.

Whatever the origin of human sexual readiness, no known pheromone is involved as a cue for human sexual activity. In humans the cues for sexual arousal seem to be learned. Various features of the opposite sex can be sexually stimulating, and sensations may be visual, auditory, olfactory, or tactile, or even a result of imagination.

And then there is the "Calvin Coolidge effect." The story goes that President and Mrs. Coolidge were making separate tours of a farm. Mrs. Coolidge asked the guide to point out to Mr. Coolidge how enthusiastically one of the roosters was accommodating one hen after another. When the guide did so, the president is said to have replied, "Tell Mrs. Coolidge there is more than one hen." Again we see that variety of stimuli can be important. The Coolidge effect has been noted in cattle (Beach & Ransom, 1967) and in rats (Fowler & Whalen, 1961). Bolles (1975) explains that researchers working with rats

> have shown that the Coolidge effect involves more than rejuvenation of an apparently satiated male; it reflects the fact that at all times following an ejaculation the male rat is more responsive to a new female than to the familiar one. The effect makes sense for animals, such as cattle and sheep, that have a "harem" type of social organization, as well as socially promiscuous and polygamous animals, such as rats. (p. 175).

Patterns of Human Sexual Response

Although Alfred Kinsey was an entomologist (a biologist who specializes in insects), it was he who broke the ice regarding sexual research on humans. He and his colleagues interviewed some five thousand men and six thousand women, and reported their findings in *Sexual Behavior in the Human Male* (Kinsey, Pomeroy, & Martin, 1948), and *Sexual Behavior in the Human Female* (Kinsey, Pomeroy, & Gerhard, 1953). Both were immediate best-sellers. These works reported extensively on what Caucasian Americans of the 1940s said they did and didn't do, and had and hadn't done. Although city dwellers with some college education are better represented in the sample than are other groups, all socioeconomic and educational classes are represented.

The main object of the Kinsey studies was to discover the frequency and nature of "sexual outlets." These included heterosexual intercourse, heterosexual petting (to climax), masturbation, nocturnal emission (males), homosexual "outlet," and animal contacts. In addition, subjects were categorized according to a number of criteria, including educational level attained. Differences defined by this criterion proved to be some of Kinsey's most striking findings.

It was found that men with college educations reported less than average premarital heterosexual intercourse, but higher than average premarital masturbation, petting, and nocturnal emissions, while the reverse was true for those with elementary school education only. However, the total number of "sexual outlets" was about the same. Homosexuality was greatest for those with high school educations. Interestingly, there were also educational differences in the percentages reporting marital intercourse in the nude: college-level males, 90 percent; high-school-level males, 66 percent; and elementary-level males, 43 percent. In addition, foreplay and prolongation were practiced chiefly by the more highly educated. Thus social and cultural factors appeared to have substantial influence on these behaviors.

Extramarital heterosexual intercourse was about twice as common among men as among women, but much more common for both than many people would have guessed at the time. Premarital sex was also much more common than was generally supposed. Males were found to reach the peak number of sexual outlets at age sixteen or seventeen, and gradually and steadily decline into old age, with about half being sexually impotent by age seventy-four. Females tended to peak later, and often continued to be sexually vigorous after their husbands' vigor began to wane.

The Kinsey reports were important not only because they provided solid information as to sexual behaviors of Caucasian Americans, but also because they made sex research respectable. In addition, they revealed a gap between stated American sexual *values* and sexual *practices.*

The other major investigations of human sexual behavior were carried out by gynecologist William Masters and psychologist Virginia Johnson, who wrote *Human Sexual Response* (1966). These studies dealt mainly with physiological responses occurring in ten thousand heterosexual encounters by seven hundred volunteers.

Unlike the Kinsey reports, *Human Sexual Response* was written in highly technical terminology and is very difficult for the average person to understand. Nevertheless, it is another valuable contribution to our understanding of sexual behavior, and was a further step in bringing sex out of the closet. Masters and Johnson chose volunteers who were of above-average intelligence and from higher socioeconomic backgrounds, so that they could better understand the nature and purpose of the study and be more articulate when answering questions. The focus of the study was on defining and describing physical changes that develop during human sexual response cycles — in other words, the reactions of the human *body* to sex. Among their findings were that human physiological reaction to sex is the same whether the sexual activity is homosexual, heterosexual, or masturbatory, or whether the participants are married or unacquainted; that all women are capable of orgasm; that women may experience multiple orgasms; that there is only one kind of female orgasm (two, vaginal and clitoral, have been suggested); that the size of the male organ is unrelated to sexual prowess; and that sexual activity often continues into old age.

Both the Kinsey and the Masters and Johnson studies were done with volunteers, and it could be argued that people who are willing to participate in such projects may not be representative of the general public. However, subsequent experience tends to support the results of both studies. While it seems unlikely that the strictly physiological responses studied by Masters and Johnson would be substantially different for other groups of people, their methodology has been questioned recently, and full acceptance of their ideas is in a state of flux. Neither the Kinsey nor the Masters and Johnson studies dealt much with the psychological factors involved in sexual arousal, but both studies are important for our knowledge of sexual behavior generally, and for therapy in particular.

Social Motives

A large number of motives have been mentioned in the psychological literature. The vast majority of these are social motives. Others have to do with the maintenance or improvement of the welfare of the individual in ways that are not necessarily social, but could be. For example, social motives that are frequently mentioned include affiliation, achievement, and power. On the other hand, competence, self-actualization, and the avoidance of injury or death are not necessarily social, but could have social value or other social implications.

Achievement is one area that has been studied extensively as a motive, but research has thus far not supplied very satisfactory answers except in special cases. For example, research tells us some things about achievement motivation for males growing up in business and industrial segments of our society, but achievement motivation in females "is still a puzzling problem" (Lamberth, 1980). Horner (1972) suggests that women have a fear of success, and in fact speaks of a "motive to avoid success." The alert student is probably falling out of his, or particularly her, chair about now and asking the question: Avoid suc-

Achievement often requires care and patience.

cess *at what?* At being a corporation executive, a teacher, a physician, a nurse, a caregiver, a person?

The problem, of course, is that achievement and success are not what has been studied; this research has examined certain *types* of achievement, or attitudes or behaviors the researchers *believe* would lead to certain types of achievement and success. In much of modern American society a person who makes a lot of money or reaches a high position has "achieved" and is a "success," even if that person is a complete failure as a spouse and parent and is in fact very unhappy.

Unit VI of this book deals with several social motives, such as those associated with affiliation, approval, agonistic behaviors, bonding, conformity, and prosocial behavior. It is interesting to note that these and other motives all contribute to biological success, and probably did so for our ancient ancestors. Biological success, or fitness, depends on the ability to cope with the environment and survive in a manner sufficient for the production of viable offspring. It is a requirement of all biological systems; the alternative is extinction. Motives can be seen as ways of fulfilling the fitness requirement, which is approximately the same for primitive and advanced societies. But the manner in which motives can be satisfied will vary with the particular society, or segment of society, in which the individual exists. In other words, different groups adopt different strategies for satisfying motives. Challenges for a member of a hunter-gatherer society are quite different from those for a teenage high-school dropout in the United States today, and challenges for a college graduate are different from either. The various segments of world society achieve fitness in different ways.

Emotion

The topic of emotion is closely related to that of motivation. We experience the internal state of arousal that characterizes motivation as a feeling or mood, terms that are synonymous with emotion. For example, the internal state of arousal associated with sexual motivation often translates into the emotional experiences of excitement, joy, or love. Such feelings, and the connotations we place on them, can serve to further increase motivation. Thus, emotions can both arise from and influence motivation.

The adaptive value of having emotional experiences seems clear. Emotional states can serve to motivate behaviors that contribute to survival. Feeling afraid when confronting a grizzly bear in the woods can provide an immediate stimulus to find a quick means of escape or defense. In addition, being able to *express* emotional states can serve important communicative functions that, again, may contribute to biological success. For example, yelling for help at the sight of the approaching bear can signal others nearby that you are in great danger, thus increasing your chances of survival.

Describing Emotion

Although it may be difficult for psychologists to agree upon a single conceptual definition of emotion, some general characteristics can be identified: (1) Emotion refers to an internal (physiological) state of arousal—for example, a change in heart rate and breathing pattern. (2) Emotion can intensify behavior, as when one's voice is raised in anger. Or it can disorganize behavior—for example, panicking as a result of fear. (3) Emotion, in humans, is associated with a conscious experience that can be labeled — for example, telling someone, "I feel depressed." (Hoyenga & Hoyenga, 1984).

Often, there are external stimuli that appear to elicit emotional responses; for example, a parent who has returned home after being away for a long time may elicit feelings of love and security in his or her children. However, there are situations in which emotional responses occur without any apparent external stimulus. It seems to be a common experience, for example, to feel a sense of loss, nostalgia, or pleasure when we reminisce about a friend or loved one who is no longer with us.

Because the subjective component is so predominant in emotion, it is understandably difficult to investigate emotional phenomena scientifically. Usually, researchers in this area restrict themselves to relatively narrow operational definitions of emotion in the interest of objectivity. For example, emotion in nonhuman subjects is typically inferred from directly observable responses to situations that are assumed to be emotionally arousing. It would be reasonable to assume that rats placed in a chamber in which they have received electric shocks will experience a high level of emotional arousal. When animals are actually placed in this kind of situation, their behavior usually differs markedly from what it would be in "nonemotional" situations. For instance, rats may defecate more than usual, or may "freeze." Researchers infer that this behavior is emotional in nature and indicates the specific emotion of fear.

This cat is displaying a typical feline fear reaction.

Other commonly used operational indicators of emotion in human and nonhuman subjects are various facial and other bodily gestures; vocalizations, such as alarm calls in birds and nonhuman primates, and crying or laughing in humans; various approach and avoidance behaviors, such as running toward or away from a stimulus; sexual responses; physical or verbal aggressive behavior; and physiological responses, including changes in heart rate, blood pressure, breathing, brain waves, and hormonal concentrations. In the study of human emotion, introspective reports, in which subjects describe their own feelings, and responses to standardized questionnaire items are also used as measures of emotion. Unfortunately, the measure that seems to be the most direct indicator of the subjective features of emotion — introspective reports — is also the one most fraught with problems of interpretation. As we saw in Chapter 3, introspection is a highly subjective method of research. How do we know that subjects actually feel what they report they feel, or that they have labelled an emotional experience accurately, or that they can identify the cause of an emotional change? In fact, Nisbett and Wison (1977) have presented evidence to suggest that subjects are often inaccurate in identifying actual causes of their emotional experiences.

Emotional Expression One particular measure of emotion—facial expression—has been the subject of scientific (and not so scientific) interest for a long time. Scientific interest in facial expression of emotions was stimulated by Charles Darwin in the nineteenth century. In *The Expression of Emotions in Man and Animals* (1872) he presented evidence for emotional continuity between human and nonhuman species: "The community of certain expressions in distinct though allied species, as in the movements of the same facial muscles during laughter by man and by various monkeys, is rendered somewhat more intelligible, if we believe in their descent from a common progenitor."

There is now a good deal of evidence to indicate universality among humans in the interpretation of facial expressions of certain emotions. The evidence is most clear for the emotions of happiness, anger, disgust, sadness, and fear or surprise. In other words, people from a variety of cultures tend to interpret certain posed or spontaneous facial expressions in the same way. This has been demonstrated across a range of cultures from the preliterate to the literate and from those with little or no exposure to mass media to those, such as our own, that are saturated with television, movies, and the printed word (Izard, 1971; Ekman & Oster, 1979). This, together with evidence from developmental studies showing a very early emergence of emotional expression and interpretation in infancy, suggests that elements of the ability to recognize and interpret correctly certain expressions of emotion may be innate.

Most people, regardless of culture, interpret facial expressions of certain emotions in the same way. Do you think this person is disgusted, fearful, happy, sad or surprised?

Although there is some evidence for cultural variation in emotional expression, the relevant studies appear not to have controlled for observer or sampling bias and did not take into account the possibility of differences in *display rules* for managing emotions. **Display rules** are socially approved ways of expressing emotion that are learned from one's culture. Thus, although two people from different cultures agree that a certain facial expression reveals sadness, there may be differences in the way they use the expression; for example, one may "wear a sad face" more often than the other. These cultural differences relate to the *management* of a given emotional expression, rather than to the ability to use or interpret the universal expression (Ekman & Oster, 1979).

How Does Emotion Work?

Several ideas have been proposed to clarify the mechanisms underlying emotion and its expression. The earliest theory, formulated independently by the American psychologist and philosopher William James and the Danish physiologist Carl Lange, stimulated a good deal of scientific investigation of emotion.

The James-Lange Theory The basic tenet of the James-Lange theory is that external stimuli elicit autonomic and skeletal reflexes and that emotion consists of feedback from that reflex activity. As described by James,

> Common-sense says, we lose our fortune, are sorry and weep; we meet a bear, are frightened and run; we are insulted by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is incorrect, that the one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble, because we are sorry, angry, or fearful, as the case may be. . . . Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colorless, destitute of emotional warmth. We might then see the bear and judge it best to run, receive the insult and deem it right to strike, but we should not actually *feel* afraid or angry (1890, pp. 449–450).

According to this view, the sight of a man jumping out of the bushes and running toward you while wielding a knife would not in itself make you feel afraid. Rather, your awareness of strange bodily reactions—a hollow feeling in the stomach, a racing heart, a sudden sweat, and shortness of breath—would constitute the emotional experience of fear in this situation.

The James-Lange theory received a good deal of criticism, most notably from the physiologist Walter Cannon (1927). Cannon argued that the viscera are not very sensitive to stimuli and could not react quickly enough to account for the almost immediate emotional experiences associated with certain stimuli. In addition, visceral responses that accompany emotions such as fear can be induced artificially through the injection of certain drugs. However, such injections usually do not result in the emotion of fear, even though the internal organs are behaving as if a natural fear-provoking stimulus had been encountered. Cannon also pointed out that we experience a great variety of emotions, though many emotional experiences are accompanied by the *same* physiological reactions. Finally, it appears that emotional behavior can be elicited from certain animals, even when afferent neural connections between the internal organs and the brain are surgically destroyed.

On the surface at least, these seem to be compelling reasons for questioning the validity of the James-Lange account. However, more recent evidence suggests that the visceral afferent systems are more sensitive and complex than Cannon had believed (Carlson, 1981). In addition, Cannon centered his criticisms on the responsiveness of the viscera. In fact, feedback from *skeletal* responses to emotional stimuli is also possible, as James noted. In this regard, there are findings from clinical case studies that are consistent with the James-Lange theory. Hohmann (1966) reported that patients with spinal cord injuries (transections) seemed to experience different intensities of emotion depending on the level of the transection. Persons with high transections tended to report less intense emotional experiences than persons with low transections. This is consistent with the James-Lange theory because high transections would result in less afferent feedback from the somatic components of the peripheral nervous system.

The Cannon-Bard Theory Cannon's ideas concerning emotion, later expanded by Bard (1928), differed substantially from those of James. The Cannon-Bard theory holds that bodily sensations do not cause emotional experiences. Rather, the thalamus, the anterior portion of which lies in the limbic system of the brain (see Chapter 9), acts on higher centers of the brain to produce emotional experiences. According to this theory, the thalamus is normally inhibited by the higher centers, until an emotional stimulus is encountered. Once perceived, sensory information about the stimulus is transmitted to the higher centers by way of the thalamus. If the higher centers detect emotional content in this information, they relax the restraints on the thalamus. The thalamus then sends impulses to the higher centers as well as to the internal organs and skeletal muscles. Reception of these thalamic messages by the higher centers results in an emotional experience. The thalamic impulses sent to other parts of the body produce the various physiological responses that normally accompany emotional experiences. Thus according to the Cannon-Bard theory, the conscious perception of emotion and the autonomic and skeletal responses that accompany emotional experience are produced simultaneously.

Results of research on the nervous system have not confirmed the Cannon-Bard account of emotion. As we saw in Chapter 9, the hypothalamus—not the thalamus—and other parts of the limbic system seem to play the prominent role in regulation of emotional behavior.

The Schachter-Singer Cognitive Theory Another view of emotion, different especially from the James-Lange theory, was provided by Schachter and Singer (1962). This theory stresses the idea that the particular emotion we experience is more a matter of our *interpretation* of external stimuli than of feedback from internal organs and skeletal muscles. Schachter and Singer proposed that there is only one general state of physiological arousal associated with different emotional experiences. People will experience different emotional states because they interpret the cause of the physiological arousal in different ways. Essentially, people label the state of arousal and describe their feelings according to what they perceive to be the causes of that state at the time.

In Schachter's research (Schachter & Singer, 1962; Schachter & Wheeler, 1962), subjects were injected with epinephrine, which has a stimulating effect on the autonomic nervous system. Such injections typically produce a state of physiological arousal, including increased heart rate and blood pressure, irregular breathing, perspiration, heart palpitations, and tremors. Of course, these physiological reactions often accompany a *variety* of emotional experiences. Experimental subjects who were told that the injection was a vitamin, not epinephrine, reported *different* emotional experiences, depending upon immediate external circumstances. When such subjects were exposed to a humorous situation immediately following injection, they described their feelings as euphoric. Subjects exposed to a situation involving a display of anger by another person reported feelings of anger. In contrast, subjects who knew they had received epinephrine were much less likely to have their feelings influenced by the humorous or angry situations. These results suggest that, in the face of uncertainty over the source of internal physiological reactions, people may describe such reactions as pleasant or aversive, depending on their perception of external circumstances. However, not all investigators examining the Schachter-Singer theory have observed the same phenomenon (Maslach, 1979). Undoubtedly, our interpretations and expectations can influence the kind of emotional experiences we have. However, it is not clear that they do so in the straightforward manner described by Schachter and Singer.

The Solomon and Corbit Opponent-Process Theory Solomon and Corbit hold that stimuli that elicit an emotional experience actually elicit a *pair* of *opposite* emotional states (Solomon, 1980; Solomon & Corbit, 1973, 1974). Thus a life-threatening stimulus, such as a car traveling at 100 miles per hour through an uncontrolled intersection, may cause intense fear in a pedestrian waiting to cross the street. But the opposite emotion — relief — will also be elicited. However, this "opponent" emotion requires a longer period of time for arousal and for decay than the initial emotional state. Once the speeding car is gone, the pedestrian will begin to feel relieved, but not immediately. It probably will take some time for the person to feel a genuine sense of relief.

Note that according to opponent-process theory, relief comes not only because the aversive stimulus is gone, but because relief is *elicited* as an opponent process by the aversive stimulus. The opposing emotion of relief "subtracts" from the initial state of fear. This could be demonstrated if the pedestrian were exposed repeatedly to the same car speeding through the intersection. With repetitions of this incident, the pedestrian would experience less fear each time; in other words, ***habituation*** of the fear response would occur (see Chapter 7). Opponent-process theory holds that such habituation results from arousal and continuation of the opposite emotion — in this case, relief. Thus, at any given time, the emotional state one experiences is considered to be a summation of the two opponent processes. The first time the speeding car is encountered, the pedestrian may report intense feelings of fear if interviewed very shortly after the incident. Although the opponent process of relief has been aroused, its relatively slow rate of increase prevents it from contributing much to the resultant emotional state. If the interview were conducted a bit later, say fifteen minutes after the incident, the pedestrian's introspections would be likely to reveal less agitation than before because of the fairly rapid decay of fear and the slow decay of relief. If the interview were not conducted until several hours after the incident, the pedestrian would be unlikely to report strong feelings of fear *or* relief, since the two opponent processes would have had ample time to decay.

Casual as well as experimental observation has tended to support the opponent-process theory of emotions, and the theory seems well suited for explaining psychological dependencies and physical addictions. For example, cocaine produces feelings of euphoria, excitement, increased energy, and alertness in many people soon after injection, smoking, or "snorting." According to opponent-process theory, the opposite emotional processes are also elicited by the drug. Once the effects of cocaine have worn off, there are sometimes feelings of fatigue and perhaps depression. Such "letdowns" become more pronounced with frequent use of cocaine. With long-term use, there is increased tolerance for the drug and often apparent growing dependence upon it. Opponent-process theory would explain the dependency phenomenon by noting that increased use of cocaine would result in a corresponding increase in the intensity of negative reactions once the pleasurable effects of the drug had worn off, thus serving as a negative reinforcer for continued use. Simply put, frequent users may, over time, increase their intake of cocaine in order to negate the aversive feelings that occur when the drug is not being used. In addition, repeated use of the drug would be associated with habituation of the pleasurable feelings and thus would result in increased tolerance. Again, this would have the effect of motivating frequent users to take ever-increasing doses of the drug in order to maintain the original intensity of effect.

The comments of a former National Football League coach provide a less dramatic but no less compelling illustration of opponent-process theory at work: "'Being an assistant in Minnesota, you won so much you expected to win,' said Patera, noting that eventually people reach a point where 'winning isn't exciting anymore, but losing is depressing'" (from the *Seattle Post-Intelligencer*, July 10, 1984).

Please note that opponent-process theory is not the only way to explain drug dependency or addiction, and we do not yet know whether it is the best way to understand such phenomena. However, the theory is attractive because it proposes a way of understanding not only physical addiction to drugs, but also dependence on substances that do not appear to be physically addictive (cocaine may fall into this category). The theory can also be applied to other habitual behaviors, such as overeating or "addiction" to jogging, as well as to masochism, thrill-seeking tendencies, formation of social attachments, and a wide variety of other emotional and motivational phenomena. The opponent-process theory could as easily be considered a theory of motivation as of emotion. It could perhaps be applied as a theory of behavior in general.

Developmental Aspects of Emotion

Some indicators of emotion occur early in life, as we saw in Chapter 6. There seem to be fairly stable individual differences in temperament in newborns, and the ability to express and interpret emotional states appears early in infancy:

> Crying, the universal expression of *distress*, is of course present at birth . . . Newborn infants show expressions resembling adult *disgust* in response to unpleasant tastes. . . . These facial expressions have been found in anecephalic and hydrocephalic infants, suggesting a brain stem origin. . . . Social smiling, i.e., smiling in an alert, bright-eyed infant who is fixating the caregiver, first occurs around 3 to 4 weeks of age. . . . Laughter first appears around 4 months. . . . Three-month-olds typically become "sober" or distressed when the caregiver presents an impassive face, suggesting a sensitivity to the animation and responsiveness of naturally occurring facial behavior. . . . (Ekman & Oster, 1979, pp. 533–534).

In addition to these observations, many studies comparing identical with fraternal twins, and adopted children with both their biological and their foster parents, suggest that indirect as well as direct indicators of emotion are in-

Crying is a universal expression of distress among humans and is displayed at birth, although there has been no opportunity to learn to cry.

fluenced genetically (DeFries & Plomin, 1978; Henderson, 1982). It is also known that rats can be bred selectively for varying levels of emotionality; that is, highly emotional animals tend to produce highly emotional offspring, while those low in emotionality tend to produce offspring also low in emotionality. Emotionality in these studies refers to increased levels of arousal, presumably related to fear (DeFries & Plomin, 1978). The clear suggestion here is that there may well be a genetic basis for individual differences in the expression of emotionality in the animals tested.

Although genetic factors may predispose individuals to be more or less emotional and may help structure the basic nervous system circuitry and endocrine functions that result in the ability to express and interpret different emotional states, it is also clear that the external environment plays a significant role in influencing emotion. High levels of maternal emotionality during pregnancy are associated with increased emotionality in offspring in both human and nonhuman subjects (Thompson, 1957; Ottinger & Simmons, 1964). To make things more complicated, however, such prenatal effects appear to vary with the genotype of the offspring. Offspring bred for high emotionality appear to be more likely to show the prenatal effects than less emotional offspring (Joffe, 1969).

There have been many demonstrations of postnatal environmental effects on emotionality. Rat pups reared by highly emotional mothers tend to show more emotionality than those reared by less emotional mothers. And, conversely, rat pups made emotional through prenatal stress, and then given to low emotional mothers, apparently bring about an increase in the emotionality of their mothers (Denenberg, 1963). Perhaps the most dramatic environmental effects on emotionality are those observed in rhesus monkeys exposed to prolonged periods of social isolation (see Chapter 6). In such studies, the greatest impairment seems to be in the formation of affectional responses and the expression of normal fear. Many social isolates also show signs of apathy and inappropriate emotional interactions with others. In some cases, the parallels between these monkeys and children who appear to have experienced long periods of social isolation seem striking. Finally, it seems clear that humans and nonhumans alike can *learn* to direct their fears to a variety of objects; recall for example the "little Albert" experiment conditioning fear to a white rat (see Chapter 7).

Cognitive Processes

Chapter 11 Sensory Processes

Chapter 12 Perception

Chapter 13 Memory

Chapter 14 Conceptual Behavior and Development

UNIT V

The next four chapters are concerned mainly with the workings of the mind. However, "workings of the mind" is one of those phrases that can mean very different things to different people. To a "psychic" or spiritualist these words may conjure up images of clairvoyance, telepathy, or precognition. To Sigmund Freud, the father of psychoanalysis, the same words would have connoted mental and emotional conflicts that take place largely outside the realm of conscious awareness. John Watson, the father of behaviorism, would have dismissed the phrase *workings of the mind* as a vague, mentalistic anachronism that had no value to the science of psychology. Most psychologists of today prefer to substitute the term *cognitive processes,* a term Watson and other radical behaviorists would also find objectionable.

Since the early 1960s psychologists have viewed cognitive processes from an *information-processing* perspective. We described this perspective briefly in Chapter 2, and in Chapter 9 we described the functioning of the nervous system in terms of information processing. The information-processing model of human and nonhuman cognition is based on the operation of computers, which *detect* and *analyze* information, *store* and *retrieve* it, and *make decisions* and *solve problems* based upon information stored in *memory.* Living cognitive systems share these features with machines, although their programs are infinitely more flexible. Many psychologists believe that the information-processing model provides a way of beginning to analyze living cognitive systems that is more enriched than behavioristic (stimulus-response) models, and more objective than other cognitive theories devised thus far.

Although the various functions of information processors are interrelated, our discussion in Chapters 11 and 12 focuses mainly on detection and analysis of information. Chapter 13 deals with the storage and retrieval of information, and the last chapter in this cognitive sequence emphasizes conceptual behavior, problem-solving, and conceptual development.

11

Sensory Processes

Factors Influencing Sensation and Perception

Measuring Sensory Capacities

Sense Organs

The Sensory Registers

Chapter Preview

Sensation involves detecting and encoding information, while perception involves analysis and decoding. Sensory systems detect and process information coming from the environment. Each of the senses is specialized to detect a certain class of stimuli — radiant energy, mechanical energy, or chemical stimuli. Responses to stimuli are similar for all the senses. A stimulus is encoded in electrochemical form — a nerve impulse. Most decoding, along with sorting and integration of the information, occurs in the brain; this gives rise to our percepts.

Sensation and perception can be influenced by several factors. Noise — that is, any factor that obscures relevant stimuli — can impede perception. Adaptation means getting used to a stimulus that is present more or less continuously, so that we tend not to notice it. Motivation can affect whether or not we attend to a stimulus. And, having prior information or some expectation about a stimulus makes detection more likely.

Sensory capacities are measured by calculating absolute thresholds, the level of stimulation that is perceived on 50 percent of a number of trials. Ernst Weber, whose work helped to establish experimental psychology, developed the concept of a just noticeable difference (jnd) — the amount of change in a stimulus that is necessary to be noticed as different. Weber found the difference required is a rather constant fraction. Gustav Fechner expanded Weber's research, and argued that knowing the jnd gives us an indirect measure of sensation itself. Stevens's Power law is a modification of Fechner's thesis, by which sensation can be estimated or measured directly.

Signal detection theory considers the fact that sensitivity to stimulation can be altered by noise, adaptation, motivation, or expectation. Thus sensitivity is influenced by environmental conditions as well as sensory capacities. But sensory capacities vary somewhat for an individual, resulting in what is called *response bias.* By testing a subject under varying conditions we can construct a receiver operating characteristic (ROC) curve, which describes sensory sensitivity to stimuli.

The simplest sensory receptors are naked nerve endings (dendrites), which are stimulated directly. Sense capsules are somewhat more complex; a capsule surrounds a nerve ending, and distortion of the capsule stimulates the nerve ending. Kinesthetic receptors are complex nerve endings that provide us with information regarding position and movements of body parts.

The chemical senses are taste (gustation) and smell (olfaction). Olfaction is apparently more primitive than taste, hearing, or vision. Olfactory sensors are simply branched dendrites in the upper wall of the nasal cavities; airborne molecules must enter the mucus before they can be detected. Olfaction is useful for evaluating the suitability of substances as food, and for giving us environmental information at some distance from the source.

Taste is different from the other senses, in that it assesses materials after they are taken into the body. There are about ten thousand taste buds on the tongue, each containing fifteen or twenty taste cells with hair-like processes on their outer ends that can be stimulated by molecules.

The ears of mammals sense vibrations in the air, which results in hearing and is responsible for the sense of balance. The outer ear ends at the eardrum. The middle ear passes vibrations from the eardrum to the inner ear, which results in hearing. The semicircular canals are involved only in maintaining equilibrium. The ear evolved from the first gill openings of early fishes, and from bones that originally supported the fleshy areas between gill openings.

The evolutionary origin of the vertebrate eye is lost in antiquity. Human eyes are sensitive to what is called the visible spectrum, electromagnetic wavelengths between about 400 (violet) and 750 (red) billionths of a meter. The vertebrate eye is often compared to a camera. Light enters through the cornea, passes through the lens, which focuses and inverts the light rays, and strikes the retina, where images are formed. The photoreceptive cells of the retina, the rods and cones, convert light energy into nerve impulses. The iris controls the amount of light entering the eye by changing the size of the pupil.

There is a good deal of evidence for the idea that information detected by the senses is retained briefly in registers tied to the sensory channels. Most of this evidence concerns the visual modality, but it appears that registers exist for the other senses as well. Some psychologists hypothesize that the visual sensory register plays an important role in perception by preserving information just long enough for meaning to be extracted. It is thought that in humans the auditory sensory register is essential for speech recognition.

It is useful to think about our sensory systems not only as detectors of information about environments, but as especially sensitive detectors of *changes* that occur. Imagine yourself sitting on a hillside overlooking a green river valley on a warm spring day, comtemplating a restful view of a winding river and trees and fields and scattered clouds. Your thoughts wander to other things. Then a deer emerges from the trees. Immediately your eyes shift and focus on the moving object. The deer browses among the shrubs at the edge of the trees, and shortly you again begin to daydream. A breeze comes up and you are aware of the air movement and wind sounds, for a moment. Then a dead limb falls from one of the trees, and you immediately turn and look in that direction. You lean back and close your eyes, enjoying the warmth of the sun. A cloud moves under the sun and you open your eyes to see what caused the change of light intensity; then you notice the breeze feels cool.

In the outdoors, one is often especially aware of sudden changes in the environment.

We might say that once you have looked over the valley, there is nothing more to "notice" until something changes. But when something does change, your senses are quick to notice.

Thus our senses are specially wired to detect changes in the environment. And of course they are wired to detect different classes of stimuli. For example, our visual receptors respond to *radiant energy*—actually to a very small fraction of the radiant energy that is available, what is called the visible portion of the electromagnetic spectrum. Auditory receptors respond to *mechanical* energy in the form of alternations in the air pressure (sound waves) produced by vibrations. Olfactory (smell) and gustatory (taste) senses respond to certain kinds of *chemical* stimuli.

Even though the different senses are specialized to detect different environmental information, all of the senses respond in a similar fashion: their responses take the form of electrochemical impulses—nerve impulses. For the most part, our **percepts** derive from centers in the brain that receive the various sensory impulses, sort them, integrate them, and make sense of them. The environmental events must be detected by the right sense, encoded in an electrochemical form, and then decoded by the brain in order to give meaning and coherence to the sensory information. So, as you can see, our percepts are not simple registrations of environmental events.

Even percepts that we take for granted, such as your understanding of the meanings of the words on this page, are really not so simple. They require the involvement of your entire visual information-processing system. Your eyes detect and respond to the particular pattern of radiant energy emanating from the printed symbols on the page. Light-sensitive cells send messages based on this energy to the occipital cortex at the rear of the brain for decoding. Somehow the information is matched with stored visual information in the brain, and meanings that have been associated with the symbols are retrieved. Finally, very rapid and automatic decisions are made concerning the nature and meaning of the symbols you are looking at. The ease with which the brain coordinates these perceptual activities is remarkable, considering the number of steps involved.

The various senses are not merely transducers of information; they also can shape and influence our percepts in significant ways. The anatomical design of certain sense organs contributes a great deal to perception. For example, we have two eyes that are separated from each other by a short distance so that slightly different images are cast upon each **retina,** the light-sensitive membrane at the back of each eye. This difference in retinal images contributes a great deal to our perception of depth.

There are other examples of sensory influence on perception. Our perceptions of brightness, color, contrast, movement, pitch, and loudness appear to be directly related to the number, the kind, and the sequence of visual or auditory receptors that are stimulated. The degree of receptor specialization that exists in some animal species is striking, as is the extent to which this specialization may structure perceptual experiences. Researchers have found that frogs, for example, have several classes of retinal cells in their eyes, each group specialized to detect different kinds of visual stimulation. Of particular interest are the convex-edge detectors, affectionately termed "bug detectors." This group of cells fires nerve impulses when small and round dark spots move toward the center of the visual field.

You probably are aware that much of a frog's livelihood depends on its ability to snatch flying insects out of the air, and it is not surprising that frogs have evolved perceptual-motor refinements that aid them in doing this. What is especially interesting is that the information is processed in so much detail at the level of the retina, before it gets to the brain. Processing in the retina speeds analysis, and presumably the faster the frog's percept is formed, the more effective it will be in capturing the moving prey. We might speculate that as speed of responding becomes more critical to survival, it becomes increasingly likely that sensory action alone will be sufficient to organize the percept.

Factors Influencing Sensation and Perception

Several factors can influence our sensory experiences. If you were standing near the river rapids, you might not hear the wind blowing through the trees because of the noise of the water. In this example the rushing water causes background noise. The term **noise** is also used in other contexts to designate undesirable or obscuring factors, such as the "noise" on a radar screen caused by a flock of geese. If you were presented with several odors, and only one odor was relevant, the others would constitute noise. For instance, while walking in the woods you detect tobacco smoke and skunk odor at the same time. If you are a detective tracking a pipe-smoking criminal, the skunk odor would be noise. But if you are merely out for a stroll and want to make sure you avoid that skunk, the tobacco smell would be noise.

Another factor that can influence our sensations is **adaptation.** If we are presented with any stimulus for a length of time, we tend to get used to it and may not notice it any longer. After standing by river rapids for a while, for example, you may not notice the sound of the water. It isn't that you can't hear it, but rather that your hearing has become adapted to it. Adaptation can also distort our perceptions. If you stare at the river rapids and then look away, the landscape seems to be moving in the opposite direction from the water flow.

Perhaps the best demonstration of adaptation distorting perception is to prepare three containers of water: one moderately hot, one room temperature, and one moderately cold. Place your left hand in the hot water and your right hand in the cold, and after a few minutes place both hands in the water at room temperature. If you are like most people, your left hand will perceive the water at room temperature as being cold, while to your right hand it will feel hot. Thus our perceptions are not always accurate, but may be affected by prior experience. For instance, a person used to firing a .22 caliber rifle might consider a shotgun blast to be very loud, while an artillery man might not.

Whether or not we attend to a particular stimulus can be influenced by *motivation,* a third factor that can affect sensation. If you are not very interested in a course you may have difficulty paying attention during a lecture, even though the teacher's voice is the only sound in the room. Of course, the reverse works also; if you are very interested you may absorb a great deal from the lecture, even if there is competing noise.

We are more likely to detect a stimulus if we have some *prior information* about its occurrence—some *expectation*—and less likely if we do not. For example, students in a genetics laboratory are much more likely to notice different shades of eye color in experimental fruit flies if they know in advance that they should look for these variations, and if they know how many variants there will be. Thus expectation is a fourth factor that can influence our sensory experiences.

Measuring Sensory Capacities

Thresholds

Threshold can be defined as the level of stimulus intensity at which a physiological or psychological response is produced. **Absolute threshold** is the minimum level of stimulation that will excite a receptor sufficiently to cause the stimulus to be detected. Receptors may fluctuate in sensitivity, and thus absolute thresholds vary even for a particular individual. For this reason the absolute threshold is calculated from several trials, and therefore is not actually an absolute figure. The *calculated absolute threshold* is that level of stimulation at which perception is reported by the subject on 50 percent of a large number of trials.

For example, suppose you were testing for absolute threshold for sound at a certain pitch. At the lowest levels the subject may not detect the sound at all, but as you increase volume the subject detects the sound more and more frequently. At some level the subject reports perception on 50 percent of the trials: this is the calculated absolute threshold. Of course, at still higher levels the subject will detect the sound on more than 50 percent of the trials.

Weber's Law

The research of physiologist Ernst Weber during the nineteenth century helped lead to the establishment of experimental psychology. Weber was interested in "muscle sense" and its relation to the sense of touch. He had subjects lift two weights on each trial and report whether one was heavier, and if so, which one. Using a series of trials with weights that differed by varying amounts, he measured how much actual weight difference was required before a subject would report a perceived change in weight—a **just noticeable difference (jnd).** Weber found that the heavier the initial weight, the greater the *absolute* difference in weight necessary for a jnd. This difference turned out to be one-fortieth of the initial weight. Thus for a twenty-ounce weight, a half-ounce difference would be necessary for a jnd; for a forty-ounce weight, a one-ounce difference; and for an eighty-ounce weight, two ounces difference.

Weber tried similar experiments with weights resting on the skin, and found that a difference of one-thirtieth was required for a jnd. He performed further studies testing the ability to distinguish the pitches of tones and the lengths of lines.

From his experimental results Weber generalized that a jnd must be a constant fraction for each of the senses. He also reported that there are exceptions for extreme tones. Later it was found that there are exceptions at the extremes for any sense. It also has been found that the apparent constancy of the fraction is very close, but not exact.

Gustav Fechner was a colleague of Weber's who helped pioneer the study of **psychophysics,** the relationship of physical stimuli to sensory experience. After years of duplicating and expanding upon Weber's research, Fechner put Weber's ratios into an equation, which he called **Weber's Law:**

$$\frac{\Delta R}{R} = K$$

where R is the magnitude (intensity) of a stimulus, ΔR is the change in that magnitude required for a jnd, and K is a constant derived from the left side of the equation. This means that a jnd is a constant proportion of the original stimulus, as in Weber's experiments. Put another way, the intensity of a stimulus must be changed by a certain percentage before it can be perceived as different, regardless of the original stimulus intensity. You will recall that this does not hold for very high or very low intensities; however, it does seem to work for most intensities normally encountered, except those near absolute thresholds.

Fechner's Law

Fechner thought Weber's results showed that *sensory experience* could be measured. He refined Weber's work by showing that the magnitude of sensation changes arithmetically as the magnitude of stimulation changes geometrically. This is **Fechner's Law:** $S = K \log R$, where S is the magnitude of sensation, K is a constant, and R is the stimulus magnitude. Simply stated, the magnitude of sensation perceived equals the logarithm of the intensity of the stimulus multiplied by a constant.

To summarize, Weber showed that a certain minimum change in a stimulus —the jnd—is required before we can perceive a change, and that the *percentage* change required is a constant. Fechner expanded Weber's discovery, arguing that knowing the amount of stimulus change required for us to perceive a difference gives us an *indirect measure of sensation.*

Stevens' Power Law

Several modifications of Fechner's Law have been suggested. One that has attracted considerable attention is **Stevens' Power Law.** In this case the subject is asked to rate the magnitude of sensation perceived, and this is compared with the intensity of stimulus. If a value of 1 is assigned to the volume of a sound, a value of 2 would be assigned to a sound perceived as twice as loud. Thus sensation is measured, or at least estimated, *directly.* As with Weber's and Fechner's experiments, there is variation among the senses, but for any one sense Stevens found that the intensity of sensation perceived is equal to the magnitude of the stimulus raised to some power and multiplied by a constant: $S = KR^N$, where S is intensity of sensation, R is stimulus magnitude, and K and N are constants.

Thus the basic idea of sensation and stimulation changing at different rates seems to be correct. And, of course, such a relationship makes good biological sense. We encounter a tremendous range of stimulus intensities, and a mechanism that allows sensation to change only arithmetically while stimulus changes geometrically substantially broadens the range of stimulus intensities we can deal with.

Signal Detection Theory

Earlier we mentioned that several factors can alter our ability to detect stimuli, particularly noise, adaptation, motivation, and expectation. Sensitivity to stimulation at any particular time depends not only upon our actual sensory capacities, but also upon the particular environment in which our sensory systems are operating. Signal detection theory provides a method of attempting to separate sensory and nonsensory factors.

On the basis of **signal detection theory** and related research, the absolute threshold is not so absolute (Green & Swets, 1966; Tanner & Swets, 1954). For a particular sensory system, the absolute threshold varies from individual to individual, and varies for a single individual at different times. Factors such as motivation and alertness can influence a person's ability to detect a weak stimulus. For example, a person who is drowsy may be less likely to detect a faint auditory stimulus. Conversely, a person who is highly motivated to hear such a stimulus may report hearing one when in fact none has been presented. In addition to motivation and alertness, other factors can influence the detection of a weak stimulus. The sensory system itself produces "noise" that can interfere with the detection of a particular stimulus. The point is that errors in detection may be due to things other than inadequacy of the sensory receptors. Errors that are a result of motivational, attentional, or other factors that produce noise are called *response bias.*

Researchers operating within a signal detection theory framework have devised a task that takes noise into account in estimating absolute thresholds. Such a task provides a way of evaluating response bias. Consider a task in which a weak tone is presented from trial to trial; the subject must indicate when the tone is heard by pushing a button. But some of the trials are *catch trials,* on which no stimulus is given. There are four possible results. A subject may make a *hit,* reporting a stimulus that has been given, or a *miss,* not reporting the stimulus. But the subject may also give a *false alarm,* reporting a stimulus when none was given, or a *correct negative,* reporting no stimulus when none was given. Thus with catch trials there are two ways of making errors, either with a miss or a false alarm. And along with simply *including* catch trials, we can also vary the *number* of catch trials.

By using a weak signal and varying the number of catch trials from 10 to 90 percent of the total trials, we can induce the subject to be more conservative, or less conservative. With 90 percent catch trials, the subject becomes more conservative — less likely to give a false alarm, but also less likely to make a hit. At this level of catch trials, and with a weak signal, the probability of a false alarm on any one trial is around 5 percent, but the probability of a hit is only about 30 percent. On the other hand, with only 10 percent catch trials the probability of hits reaches about 90 percent, but the probability of false alarms increases to about 50 percent.

It is not clear *how* a subject adjusts to changes in the numbers of catch trials. Nevertheless, a subject in this kind of task typically makes more false alarms if there are few catch trials, and will make fewer false alarms as the proportion of catch trials increases. The fact that varying the number of catch trials can affect accuracy in the detection of a weak signal argues against the notion of an absolute ability to detect a stimulus.

Plotting hits against false alarms, and connecting the points with a smooth curve, we obtain a **receiver operating characteristic (ROC)** curve (Figure 11.1). This curve represents the *operating characteristics* of a particular *receiver* (subject) when different percentages of catch trials are presented at a particular stimulus intensity.

Theoretically, a straight line would be generated if a subject could not detect a stimulus and simply guessed whether or not a stimulus was being presented. This is represented by the diagonal line in Figure 11.1. A straight line might occur if the stimulus was consistently below threshold, or if a blind person were trying to report light stimuli, or a deaf person sound stimuli. Thus the diagonal line in Figure 11.1 represents no sensitivity to the signal.

The amount that any curve differs from the straight line — the degree of bow, or bowedness — is designated *d′* (d prime). This is a measure of sensory sensitivity to that particular stimulus and stimulus intensity, under the conditions of the experiment. An increased signal intensity produces a curve with more bowedness, resulting in a larger *d′* and indicating a greater sensory sensitivity to the changed signal. Simply put, the stronger the signal, the more frequently the subject will detect it.

For example, suppose we provide a subject with a set of earphones through which we continuously present static, and periodically present a signal. At very low signal intensities the subject never detects the signal; this generates the straight-line ROC curve. At some higher level of intensity the subject occasionally detects the signal. According to the hearing acuity, the variation in hearing acuity, and the frame of mind of the subject (which can be affected by catch trials),

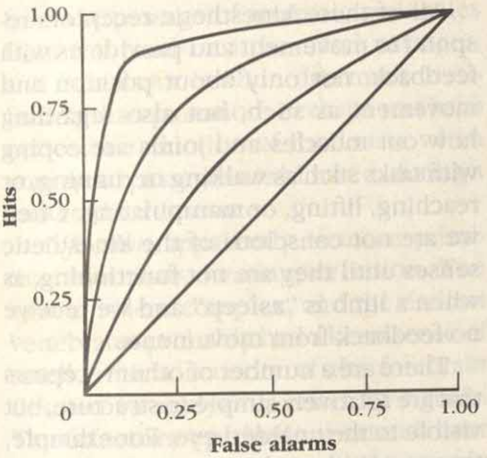
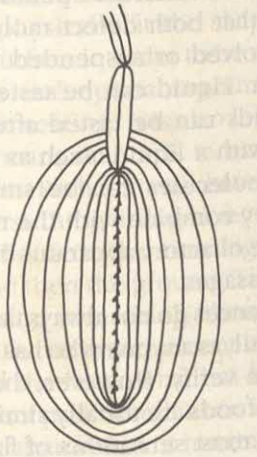


FIGURE 11.1 ROC curves. The diagonal straight line to the right could represent "detection" of light stimulus by a person who is totally blind. The curves to the left represent an increase in stimulus strength and a corresponding increase in detection.

some hits and some false alarms are expected. A curve with a small amount of bow—a small *d′*—will be generated. But as signal intensity increases further the subject makes more hits and fewer false alarms, resulting in ROC curves with more bow (greater *d′*). Thus as signal intensity increases, the subject's efficiency in detecting the signal improves—the subject is better able to distinguish signal from static.

FIGURE 11.2 Pacinian corpuscle, one type of sense capsule. In the center is a nerve ending, surrounded by about thirty to fifty onionlike layers forming the capsule.



Signal detection theory can be used in many situations where judgment is involved. It allows us to evaluate the extent to which non-sensory biases may be influencing decisions. To put it another way, the ROC curve expresses how accurately the subject detects signals, or how efficiently the subject distinguishes sensory stimuli from non-sensory biases.

Sense Organs

Relatively Simple Receptors

Sensory structures located in the skin keep us informed of certain aspects of our environment. *Naked nerve endings*—dendrites not associated with another structure involved in sensation—receive input from various stimuli, such as touch, pressure, stretch, heat, cold, and pain. In addition, several types of *sense capsules* are located in the skin and in connective tissues, which also appear to monitor touch, pressure, heat, cold, or pain. Sense capsules surround nerve endings, and distortion of the capsule results in stimulation. The best-understood capsules are the pacinian corpuscles (Figure 11.2), which consist of a number of onion-like layers. Distortion of these layers by pressure stimulates the enclosed nerve ending. The sensory functions of other types of capsules are less well understood. It is possible that some of them may be sensitive to more than one type of stimulus.

The movement and relative positions of various parts of the body are detected by **kinesthesis,** the so-called muscle sense. Movement is often necessary for perception to occur; this is particularly noticeable when awakening from sleep. There are three kinds of kinesthetic structures:

1. A *muscle spindle* is a muscle fiber that is surrounded by a net of nerve endings. Stimulation occurs when the muscle is stretched. Muscle spindles are most abundant near where muscle merges with tendon.
2. *Tendon organs* are complex nerve endings located where tendons join bones. They are stimulated when the muscle contracts.
3. *Joint receptors* are complex nerve endings in the connective tissue of joints, and stimulation occurs when there is movement in the joint.

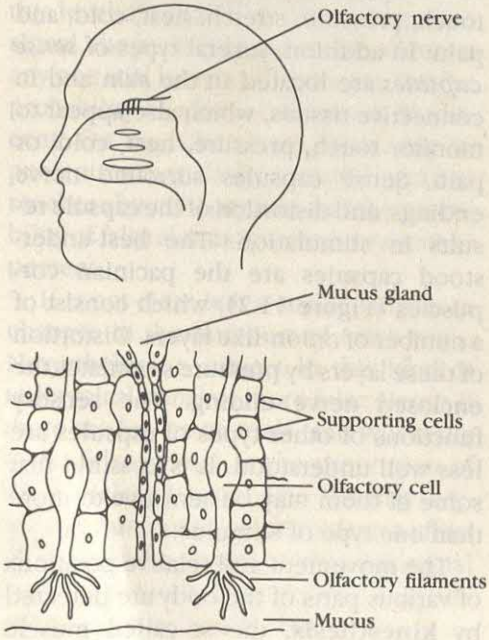


FIGURE 11.3 Olfactory nerve endings in nasal epithelium. Odors are absorbed by mucus covering the nasal epithelium and stimulate the olfactory filaments.

All of these kinesthetic receptors respond to movement and provide us with feedback, not only about position and movement as such, but also regarding how our muscles and joints are coping with tasks such as walking or running, or reaching, lifting, or manipulating. Often we are not conscious of the kinesthetic senses until they are not functioning, as when a limb is "asleep" and we receive no feedback from movements.

There are a number of other receptors that are relatively simple in structure, but visible to the unaided eye. For example, the *carotid body* lies in the fork of two arteries, the internal and external carotid arteries that supply the head (including the brain) with blood. The carotid body detects fluctuations in oxygen and carbon dioxide levels in the blood, and sends impulses to the parts of the brain that control respiration and circulation.

The Chemical Senses

In all vertebrates, tastes and smells are detected by different types of receptors. **Olfactory** sensors are simply branched dendrites, while **gustatory** sensors are groups of specialized cells that stimulate dendrites.

Taste and smell are operationally similar, in that both detect molecules that are dissolved or suspended in a liquid medium. Liquid can be tasted directly, and solids can be tasted after they are mixed with a liquid, such as saliva. Airborne molecules can be smelled only after they combine with the mucus covering the olfactory apparatus in the upper nasal passages.

Substances do not always taste the way they smell, as anyone who has tasted perfume can verify. However, the taste and smell of foods are usually similar. This is because most sensations of flavor result from the passage of aromatic molecules from the food into the nasal passages, and thus flavor is often due more to olfaction than gustation. Perhaps you have noticed a reduction of food taste when your nasal passages are blocked, during a bad cold for instance.

Olfaction apparently is more primitive than taste, hearing, or vision. The system is less complex, and the earliest vertebrates probably had a keen sense of smell, with a majority of the forebrain devoted to analyzing olfactory signals. The **olfactory epithelium** extends over a small area in the upper nasal passages (Figure 11.3). It is covered by a layer of watery mucus that airborne molecules must enter before they can be detected. The mucus is constantly being secreted and washed away so that new information—new molecules—can be brought into contact with the olfactory sensors.

Neurons interspersed with supporting cells make up the olfactory epithelium. Odors are detected by hair-like branches of dendrites that are exposed to the mucus. The axons of these neurons connect directly with the olfactory bulbs of the brain. Apparently a single dendrite branch can only respond to one particular material, and a molecule of that material must physically fit the shape of the receptor surface in order to be detected.

Smell is less important to humans than is vision or hearing. It is also less important to humans than it is to many other vertebrates. Perhaps you have noticed that the first thing a dog does when let out of the house in the morning is to sniff the air, and then the ground. The former tells the dog something about what is going on in the environment at the moment, and the latter what has happened in the recent past. Smell is less important to humans than vision or hearing, but it is useful for such things as indicating the suitability of foods and for giving us environmental information at some distance from its source.

Our chemical senses often provide pleasant experiences.

Many animals use pheromones to pass information among individuals. In particular, pheromones inform males of many species of the sexual readiness of females. We mentioned in Chapter 10 that pheromones are unknown among humans. It is interesting in this connection that the sexual pheromone produced by female rhesus monkeys is a fatty acid, and that the substance that

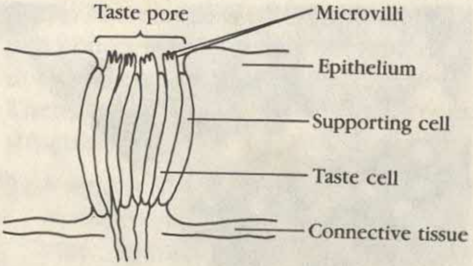


FIGURE 11.4 A taste bud is stimulated by materials absorbed by the saliva.

causes human perspiration to smell is also a fatty acid, and is not produced until puberty.

Taste is different from the other senses in that its primary value is in assessing materials after they are taken into the body. Olfaction often tells us whether a substance is likely to be suitable as food, but the taste buds provide the decisive information.

There are about ten thousand taste buds on the tongue of humans, each containing fifteen or twenty taste cells. Hair-like processes on the outer end of the cells can be stimulated by molecules at or near the pore of the taste bud (Figure 11.4). Dendrites in contact with the cells then pass stimuli to sensory nerve fibers.

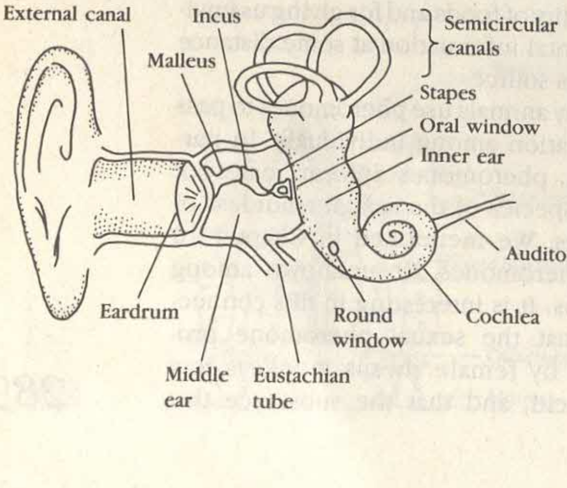


FIGURE 11.5 Structure of a human ear. Pressure from sound waves striking the eardrum is transmitted to the oval window of the inner ear by the malleus, incus, and stapes. This causes pressure in the cochlea, resulting in the transmission of impulses by the auditory nerve.

Taste buds are concentrated at the tip, sides, and back of the tongue, but some also occur on the soft palate and in the throat. In general, each taste bud is most sensitive to one of the four basic tastes — sweet, salty, sour, and bitter. One taste cell is sensitive to only one type of molecule, but there is some evidence that different taste cells can occur in one taste bud. And taste buds sensitive to all four tastes occur in each of the tongue areas mentioned. However, the greatest concentration of taste buds is as follows: sweet at the tip, salty near the tip, sour on the sides, and bitter at the back.

The Ear and Hearing

The function of the ear of mammals is twofold. It senses vibrations in the surrounding air, resulting in what we call hearing, and is also responsible for our sense of balance.

The *outer ear* includes the flap of skin and cartilage, the **pinna,** which is mainly ornamental in primates, and a blind tube extending a short distance into the head and ending at the eardrum **(tympanum).**

The *middle ear* is an air-filled space beyond the eardrum, which is almost completely surrounded by bone of the skull. It connects with the throat by means of the **eustachian tube,** through which the air pressure in the middle ear is kept about the same as the air pressure outside the body. This normally protects the eardrum from bursting due to excessive pressure on either side (Figure 11.5).

The middle ear cavity contains three small bones, the **auditory ossicles,** which are attached in series and are essential for our hearing. The **malleus** (hammer) is attached to the inner surface of the eardrum and is moved when air vibrations strike the eardrum. The malleus moves the **incus** (anvil), which in turn moves the **stapes** (stirrup). The stapes vibrates against the **oval window**, an opening in the bone housing of the inner ear. The oval window has only about one-twentieth the area of the eardrum. Due to the lever action of the auditory ossicles, and the relatively small area of the oval window, the force of the air vibrations hitting the eardrum is increased about twenty times at the oval window. Because liquid is much more difficult to set into motion than air is, an increase in force is necessary to cause motion in the liquid beyond the oval window, in the cochlea.

The *inner ear*, also housed within the bone of the skull, consists of the (upper) vestibular sacs and semicircular canals and a lower sac and cochlea. The **cochlea** is a dead-end spiral tube filled with liquid. It is divided for most of its length into upper and lower portions by the **basilar membrane.** Groups of hair cells, the **organs of Corti,** are attached to the basilar membrane, with their sensory hairs embedded in the less extensive tectorial membrane. Displacements of the oval window cause pressure waves in the liquid of the cochlea and displacements of the membranes. This results in stimulation of the hairs, which in turn stimulate the auditory nerve. The basilar and tectorial membranes do not quite extend the full length of the cochlea, so that pressure waves pass around the end of the membranes and return along the other side to distort the round window into the air cavity of the middle ear. In this way the pressure waves leave the cochlea (see Figure 11.5).

The semicircular canals and associated vestibular sacs do not play a role in hearing, but are involved in maintaining equilibrium. Hair cells in these structures also play the key role in their functioning.

The position of the head is detected by hair cells in the **vestibular sacs.** According to what position the head is in, the calcium coverings of certain hair cells exert a slight shearing pressure on the hairs due to gravity, and this produces a stimulus. Other hair cells, which are not in a position for their coverings to be moved by gravity, are not affected. In this way the position of the head is sensed.

The three **semicircular canals** have groups of hair cells at one end that are covered by a jelly-like substance that is easily compressible. Each canal lies in a different plane, with the result that *movement* of the head in any direction is detected by at least one of them. When the head is moved in the plane of a particular semicircular canal, the liquid in the canal moves, distorting the jelly and stimulating the hairs at the end of that canal.

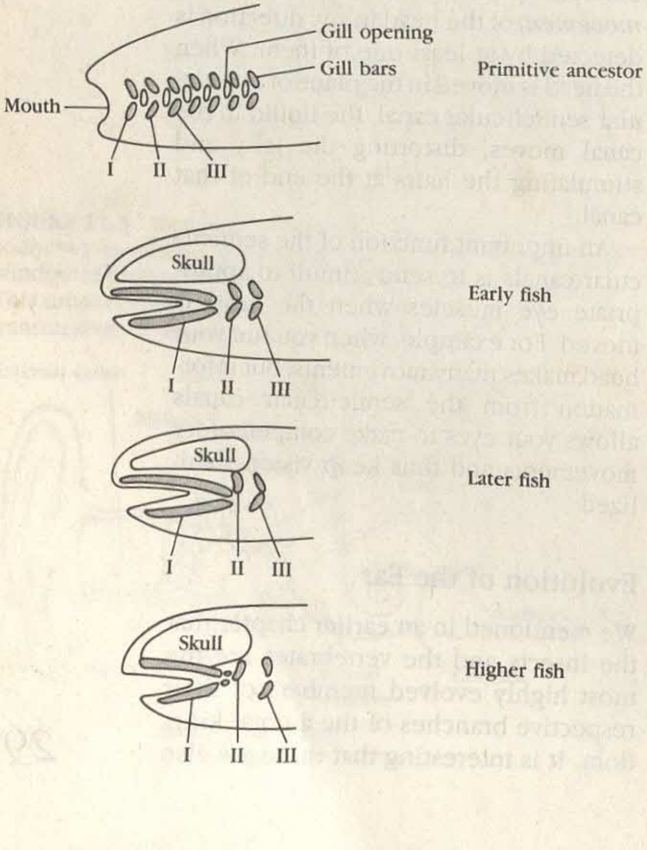
An important function of the semicircular canals is to send stimuli to appropriate eye muscles when the head is moved. For example, when you run your head makes many movements, but information from the semicircular canals allows your eyes to make compensatory movements and thus keep vision stabilized.

Evolution of the Ear

We mentioned in an earlier chapter that the insects and the vertebrates are the most highly evolved members of their respective branches of the animal kingdom. It is interesting that these are also the only two groups to have developed specific structures for hearing. Although their hearing evolved independently, in both insects and four-footed vertebrates sound detection is based on vibration of a membrane by airborne sound waves.

Most of the details of the origin of the vertebrate ear are unknown, but some evidence is available from primitive fishes and from embryo development. The parts of the inner ear associated with maintaining equilibrium are present in all vertebrates, although in primitive fishes they are developed less than in other vertebrates. These structures arise from a group of cells on the surface of the embryo, the ectoderm, which sink inward and develop dorsal and ventral sacs. The semicircular canals develop as extensions from the dorsal sacs, and the lagena as an extension from the ventral sac. The lagena becomes elaborated as an organ of hearing in more advanced vertebrates, and finally evolves to become the cochlea of mammals (see Figure 11.5).

FIGURE 11.6 Evolution of the ear. I = 1st gill bars; II = 2nd gill bars; III = 3rd gill bars. The first gill bars become the jaws, the second become the ear bones.



In fishes a lateral line system extends along the side of the animal, containing sensory pits with hair cells. The lateral line system "hears" water vibrations from close by, and helps detect the presence of other organisms and of obstructions such as rocks or corals. In some of the more highly evolved fishes a limited amount of distance hearing occurs in the inner ear, due to vibrations transmitted to it by long extensions of the abdominal gas bladder. Thus, while balance in fishes is similar to that in mammals, hearing is quite different.

The middle ear evolved as four-footed vertebrates evolved. In Chapter 4 we mentioned that grooves representing the gill slits of primitive fishes develop in mammalian embryos. Fishes such as sharks have a series of gill slits that open internally into the mouth. The first gill opening, called the spiracle, is greatly reduced but maintains a tube-like connection with the throat. The fleshy areas between the gill openings are supported by pairs of bones between them, the upper and lower gill bars. (Actually, the "bones" of sharks are composed of cartilage.) The jaws evolved from what was once the first pair of gill bars, and in primitive forms the upper jaw is not firmly attached to the skull. In sharks, the upper part of the second gill bar has evolved to form a support between the rear part of the upper jaw and the skull in the area of the inner ear. But in higher fishes the upper jaw has become fused with the skull. Thus the second upper gill bar is relieved of the supporting function, but is still in contact with the skull in the vicinity of the inner ear, and with two of the bones that form the jaw joint in fishes (Figure 11.6).

The middle ear began evolving in primitive amphibians and reptiles. The position of the upper second gill bar remained approximately the same, but was modified to become the stapes. The oval window developed, connecting the stapes with the inner ear. The first gill opening evolved to a different position so that the stapes now lies within it, and its connection with the throat became the eustachian tube. And the lagena (the future cochlea) of the inner ear became more highly developed.

With the evolution of the mammals, the evolution of the middle ear was completed. The stapes shortened and the two jaw-joint bones migrated inward and became modified to form the incus and malleus. The first gill opening is still represented by the eustachian tube, the air space of the middle ear, and the tubular outer ear. The eardrum separates outer and inner portions of what was once the first gill opening.

The Eye and Vision

Our eyes are sensitive to electromagnetic radiation of wavelengths between about 400 (violet) to 750 (red) nanometers (billionths of a meter). This is the visible spectrum, so called because it is visible to humans. Many animals have somewhat different limits. Most insects, for example, cannot see red, but can see ultraviolet. Most of what we see is a result of light being *reflected* off the object or objects we are viewing, although of course we can see light produced *by* objects being viewed, such as the sun, light bulbs, and fireflies.

The vertebrate eye is often compared with a camera, and indeed there are many similarities. The lenses of both invert the image projected on the sensitive surface. Focusing and light control also work similarly, but in addition the eye has its own cleaning and lubricating system.

Light enters the eye through the cornea, passes through the lens, and strikes the retina, where an image can be formed (Figure 11.7). The **cornea** is responsible for most of the bending (refraction) of light waves entering the eye. The front surface of the cornea is bowed, so that light waves entering near the edges are bent more than those entering near the center. The result is that the image cast on the retina is inverted.

Focus (visual accommodation) is accomplished by the **lens,** which is immediately behind the cornea. The lens reduces the refraction caused by the cornea, the degree of change depending upon the shape of the lens. The lens is held in place by the *suspensory ligaments.* The eye at rest is accommodated (focused) for distance vision because it is kept relatively flat by tension exerted by the suspensory ligaments. In order to focus on something close at hand, the **ciliary muscles** contract; this reduces

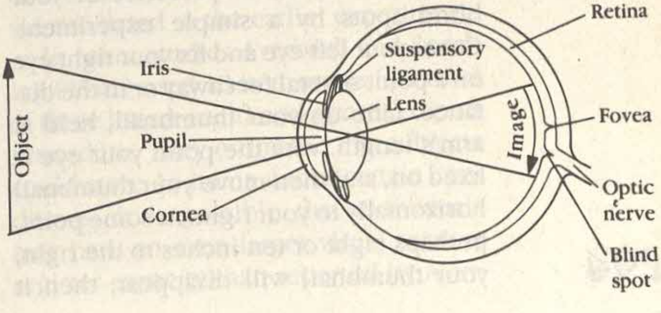


FIGURE 11.7 Structure of human eye showing inversion of image.

the tension on the suspensory ligament and allows the lens to assume a more rounded shape, the shape it assumes if it is detached from the suspensory ligaments.

Image formation occurs in the *retina,* the light-sensitive area that covers the inside of the eyeball behind the lens. The retina consists of three layers, which are, in effect, inside out with regard to what might be expected when considering their function. The photoreceptive cells, the **rods** and **cones,** are on the outside of the retina, aimed away from the source of stimulation. The rods and cones convert light energy into nerve impulses. The **bipolar** cells, the middle layer, synapse with the rods and cones and pass impulses to the *ganglion cells,* which are on the inner layer. Axons from ganglion cells converge to form the optic nerve.

You may have noticed that the eyes of some animals, such as housecats, "shine" in the dark. Many nocturnal animals have a reflective pigment layer, the tapetum, underlying the retina, that reflects light back to the light-sensitive cells and thus increases the amount of light they receive. In some animals that are partly diurnal, black pigment disperses and covers the reflective surface during the day.

The point at which the optic nerve passes out of the retina (and out of the eyeball) is a **blind spot,** because photoreceptive cells are not present there. You can demonstrate the presence of your blind spots by a simple experiment. Cover your left eye and fix your right eye on a point several feet away or in the distance. Line up your thumbnail, held at arm's length, with the point your eye is fixed on, and then move your thumbnail horizontally to your right. At some point, perhaps eight or ten inches to the right, your thumbnail will disappear; then it will reappear as you continue to move it to the right. The same exercise in reverse will locate the blind spot in your left eye.

Near the blind spot is the **fovea,** which is the only area of the retina at which a really sharp image is formed. Cones are most concentrated here, and no rods are present. Although the fovea is very small, we can still see all parts of a fairly large image clearly because our eye muscles constantly cause slight flicking movements of the eye. Thus one part of the image and then another are cast on the fovea, and a clear total image is perceived.

The amount of light entering the eye can be affected by adjustments of the **iris** that cause changes in the size of the pupil. In bright light the pupil is small, reducing the amount of light entering the eye; in dim light the pupil is large, making it possible for more light to enter.

Over time light-sensitive structures have evolved independently in several groups of animals. The most highly developed are the eyes of vertebrates, those of insects and other arthropods, which are quite different from ours, and those of octopuses, which are very similar to ours but evolved independently.

The evolutionary origin of vertebrate eyes is not known. This is because the first vertebrates we know of already had them full-blown, and because the light-sensitive structures of more primitive animals in the evolutionary line leading to the vertebrates bear little resemblance to vertebrate eyes.

The Sensory Registers

So far we have emphasized the senses as *detectors* of information, especially of changes in the environment. Detection is the first step in perceiving the world around us, a phenomenon that will be treated further in the next chapter. But in order for perception to occur, something more than momentary detection of a stimulus may be required. There must be a way of *retaining* the detected information long enough for perceptual analysis and understanding to take place: information processing takes time. Research suggests that the senses themselves may retain information, briefly but nevertheless long enough for such processing to result in a percept. This section deals with the "memory stores" of the senses—the **sensory registers.**

Imagine yourself in a severe electrical storm on a dark August night on a midwestern prairie. As you are driving along, a streak of lightning arcs over a field off to your left. Although the lightning flash was brief, lasting a matter of milliseconds, you are able to make out a barn, a house, a few trees, and a fence in the field. In fact, the illuminated picture persists a bit longer than the lightning flash itself. This is an example of *visual* sensory register, sometimes called **iconic memory.** There also appears to be an *auditory* sensory register, sometimes called **echoic memory.** It is assumed that the other senses have such registers as well.

The sensory registers appear to be relatively large-capacity memory stores from which information is lost rapidly unless further processing occurs. Information in the sensory registers appears to exist in raw, physical form. Thus, information in the visual sensory register would consist of shapes, patterns, and variations in brightness and color. Information in the auditory sensory register would consist of acoustical properties such as variations in loudness, pitch, and timbre (distinctive tonal quality).

Visual Sensory Register

In 1960 George Sperling reported a series of experiments that formed the basis for a strong argument for the existence of a visual sensory register in humans. In one experiment Sperling presented a large number of different arrays of letters or digits visually for adult subjects. A given array would be flashed on a screen for only fifty milliseconds (one-twentieth of a second), and the subject was asked to write down the items seen and indicate their locations. On the average, subjects were able to recall a relatively small number of items in their proper locations. In an array of 12 items—three rows of 4 items each—recall averaged only 4.3 items.

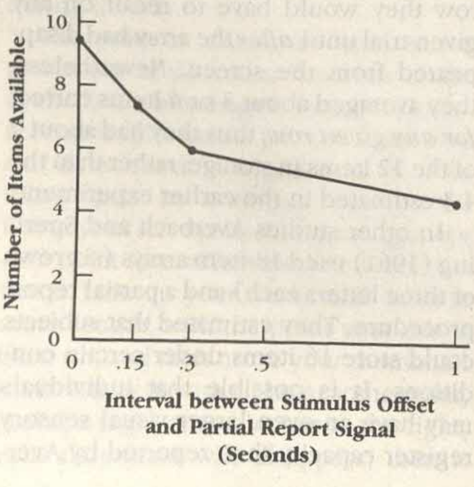
But in later experiments Sperling found that he had underestimated the capacity of the visual register. Apparently, in the time required to write down all of the items seen, the fragile image had been lost. Sperling demonstrated this by using a *partial report* procedure. He again used the 12-item array, but instead of asking subjects to recall all 12 items, Sperling had them report only one row (4 items)—top, bottom, or middle. However, subjects never knew which row they would have to recall on any given trial until *after* the array had disappeared from the screen. Nevertheless, they averaged about 3 or 4 items correct *for any given row;* thus they had about 9 of the 12 items in storage, rather than the 4.3 estimated in the earlier experiment.

In other studies Averbach and Sperling (1961) used 18-item arrays (six rows of three letters each) and a partial report procedure. They estimated that subjects could store 16 items under certain conditions. It is possible that individuals may have an even larger visual sensory register capacity than reported by Averbach and Sperling; there is no established upper limit on the capacity of this system.

The *duration* of information in the visual register has been assessed in a number of ways. The most straightforward involves varying the interval between the termination of the stimulus and the signal to recall. Based upon this and other techniques, it appears that information in the visual register is seriously eroded within one second (Figure 11.8).

We mentioned earlier that the content of the sensory registers is presumed to be sensory in nature. Subjects in experiments such as Sperling's often report that they "see" the stimulus for an instant after it is removed. More systematic evidence concerning the nature of information in the visual register comes from attempts to vary the brightness of the visual field following presentation of the stimulus. For example, in the study by Averbach and Sperling (1961), the best recall occurred when the array of items was followed immediately by a *dark* visual field. When the array was followed by a light field, recall was reduced dramatically. This indicates that it is possible to interfere with information in the visual register using other *visual* stimuli. More recent studies confirm the sensory nature of the *icon* and leave little doubt that it can function as a faithful reproduction of the physical stimulus (Loftus, Johnson, & Shimamura, 1985).

FIGURE 11.8 Number of items estimated available in the visual sensory register for different intervals between stimulus offset and signal for partial report.



The apparent sensory nature of information in the visual register suggests the possibility that the light-sensitive receptors in the retina of the eye may be responsible for this kind of memory.

> Where is iconic memory located? A number of findings indicate that long-lasting afterimages are localized in the retina, and it would be parsimonious to assume a retinal location for iconic storage as well, since a known physiological mechanism exists that could produce such iconic memory. The mechanism is as follows: light bleaches the pigment molecules in the visual receptors (rods and cones) of the eye, and this activates the peripheral neurons in the visual system. This activation in the retina is known to persist for some time following termination of the stimulus, possibly because the rods and cones require time to become unbleached. . . . On the basis of our physiological knowledge . . . , one would expect that most, if not all, of iconic memory is located in the rods and cones themselves (Wickelgren, 1979, p. 195).

The significance of the visual sensory register is a subject of debate (Bruce, 1985). Some psychologists argue that it plays an important role in perception by preserving information just long enough for meaning to be extracted (Jonides, Irwin, & Yantis, 1982). This may or may not be the case when one looks at something for a relatively long period of time, since meaningful percepts can then be formed directly from the sensory input. That is, there may be no need to preserve information that is continuously coming into our senses in order to make sense of it. However, in cases of *brief* glimpses of visual stimuli, it would be very adaptive to have a means of preserving the information.

Perhaps a more fundamental issue concerns the content of the visual sensory register. Many cognitive psychologists assume that raw (unprocessed) features of the visual environment reside in the visual sensory register, awaiting some sort of recoding into a form (usually linguistic) that will yield a meaningful percept. A difficulty, perhaps insurmountable, is that there is currently no way to provide direct evidence for this view. When subjects report what they see in visual sensory register experiments, the information they are reporting has already been recoded by the time they are first aware of what they have seen. Thus it is difficult to do much more than speculate about the "unrecoded" contents of the visual sensory register (Kolers, 1983).

Auditory Sensory Register

Less is known about nonvisual sensory registers, but there is at least some evidence suggesting the existence of an auditory register. This evidence comes mainly from variations of **dichotic listening** studies. In a dichotic listening task, a subject hears two different messages simultaneously. The experimenter may ask the subject to attend to one message, but then ask for a report on the other. Subjects have difficulty recalling information from the nonattended message, especially if the attended message requires a great deal of concentration. However, if there is little or no delay between the offset of messages and the signal to recall, *some* information is reported accurately. In fact, an auditory experiment analogous to Sperling's showed that auditory register capacity was greater when partial report procedures were used than with the whole-report method. This study had subjects listen to *four,* not two, simultaneous messages, one of which (chosen at random) was to be reported (Moray, Bates, & Barnett, 1965).

Estimates of the duration of information in the auditory register vary widely, but studies along the lines of Sperling's indicate that such information lasts from about two to four seconds (Darwin, Turvey, & Crowder, 1972). And, just as with the visual register, it is possible to interfere with information in the auditory register using other auditory stimuli (Masarro, 1970). These and other data argue for a brief auditory memory that parallels the visual sensory register.

What is the significance of the auditory sensory register? It seems almost certain that this storage system is basic to achieving continuity in auditory perception. If, for example, we could perceive speech sounds only at the instant they were being uttered, it would be difficult to connect the sounds in order to perceive words, phrases, or sentences. This problem does not characterize vision, since our eyes automatically change fixation points several times per second and these movements, called **saccades,** can integrate the old information with the new, so that it is possible to achieve continuity in visual perception. But we do not have the luxury of scanning and integrating an auditory message unless the information persists beyond the physical presence of the stimulus. The auditory sensory register gives us the time we need to make sense of the world of sound. Wingfield and Byrnes (1981) explain what the absence of an auditory register might mean:

> While both visual and auditory events occur over time, auditory experiences such as the recognition of speech would be impossible without the ability to retain sensory impressions for periods longer than their actual physical duration. The average duration of a spoken syllable, such as "ga" or "be," typically takes between 200 to 300 msec (.2 to .3 sec) to produce. Although this is not a very long span of time, the recognition of such a syllable depends on the analysis of what is a constantly changing acoustic pattern over this 200- to 300-msec period. Unless we could maintain some auditory memory for at least this long, we would have lost the beginning of the syllable before the speaker had a chance to finish the end of it!(p. 169).

Developmental Aspects of the Sensory Registers

Our knowledge of the development of the sensory registers comes mainly from studies of the visual sense modality. The evidence suggests there is little developmental change in the capacity of the visual sensory register, at least between the preschool years and adulthood. However, preschoolers seem to lose information faster from this register than do older children and adults (Blake & Vingilis, 1977; Sheingold, 1973). Many researchers have interpreted this result as reflecting a lack of labeling or of rehearsing of the visual information on the part of the younger child, or both. In their view the differential forgetting of younger and older children may be due to the differential use of memory strategies that would preserve information.

Although there have been relatively few investigations of the sensory registration ability in the elderly, some studies present findings that parallel results obtained from preschool children. For example, Kline and coworkers have shown that adults averaging sixty-eight years of age appear to read out information from the visual sensory register more slowly than do twenty-three-year-olds (Kline & Birren, 1975; Kline & Szafran, 1975).

Perhaps the nervous system becomes less efficient with age, thereby impeding rapid readout from the visual sensory register. Or perhaps the brief memory traces themselves are more fragile in older people because of declining inhibitory or other functions in the brain.

It is also possible that age-related changes in the nervous system have little or nothing to do directly with the readout process or memory traces relating to the visual register. Perhaps older subjects are simply less motivated or more distracted than younger subjects when confronted with tasks emphasizing *speed* of processing. Regardless of the interpretation, the findings of Kline and others raise the possibility that memory deficits in older adults may be due in part to slower readout of information from the visual sensory register.

Perception

12

Color Perception

The Perception of Two-Dimensional Patterns

The Perception of Movement

The Perception of Depth

The Developmental Origins of Perception

Human Perception and Evolution

Supplement 1 Sleep and Dreaming

Chapter Preview

This chapter focuses on visual perceptual phenomena — color, pattern, movement, and depth — and on factors that influence their occurrence and development.

Color vision is found in a variety of animals, but different species appear to be responsive to different parts of the color spectrum. Color is characterized in terms of hue, saturation, and brightness. A *hue* is a perceived *chromatic* color. *Saturation* refers to the perceived richness of a hue, and corresponds to the purity of a color. *Brightness* is the perceived luminance or intensity.

Color mixtures can be subtractive or additive. A hue produced by a combination of pigments is called a *subtractive* color mixture. An *additive* mixture is a combination of *wavelengths,* not pigments. The notion of additive mixture is important in understanding how color vision works.

There are two major theories of color vision. The *component theory* holds that the perception of different colors is due to the *addition* of activities from three different sets of color receptors in the eye. The *opponent theory* holds that the perception of different colors is due to the fact that some color receptors, when stimulated, inhibit the firing of others.

The Gestalt psychologists believed that the perception of *two-dimensional patterns* cannot be reduced to the accumulation of individual sensations. Rather, they argued that it is the *pattern* of receptors stimulated and organization by the brain that is responsible for many of our perceptions. These psychologists hypothesized that innate principles govern the organization of pattern perception: *figure-ground,* the Laws of *Prägnanz,* and several Laws of *Grouping.*

The visual perception of movement cannot be understood without acknowledging the role of higher centers in the brain. If the retinal image is moving but the eyes are also moving, the brain decides that the object being fixated is stationary. If the retinal image is stationary but the eyes are moving, the brain concludes that the object is moving.

Both monocular and binocular cues influence our perception of depth and distance. *Monocular cues* include perceived size, linear perspective, atmospheric conditions, interposition, texture gradients, shadows, brightness and saturation of colors, motion, and accommodation. *Binocular cues* consist of convergence and retinal disparity.

It is clear that certain perceptual abilities are present so early in life that it is difficult to rule out some kind of *innate* basis for their development. A good deal of research has focused on the emergence of depth perception. The evidence to date suggests that responsivity to depth is, at least in part, based upon innate perceptual programming.

Human visual perception can be viewed as a primate adaptation that was highly successful for coping with an arboreal habitat. Once hominids began to occupy the savanna, it is likely that visual perception became even more accurate.

The supplement to this chapter discusses *sleep* and *dreaming,* rhythmic processes that involve various states of perceptual awareness.

The last chapter was concerned mainly with the structure and function of human sensory systems and their contributions to perception. This chapter focuses on well-researched perceptual phenomena — color, pattern, movement, and depth — and the reasons for their occurrence and development. The chapter is devoted almost entirely to *visual* perception, because our knowledge in this area far surpasses what is known about perception in the other sensory modalities.

Color Perception

Imagine that a narrow beam of sunlight hits a glass prism in a room that is otherwise dark. Suppose further that a white screen is located in the path of the light leaving the prism. What you would see on the screen looks like a rainbow, a band of colors in which one color gradually blends into another. The band of colors produced by sunlight falling on a prism is called a *solar spectrum,* and this phenomenon was first described by the famous English physicist Isaac Newton (1642–1727) over three hundred years ago. Newton's experiments showed that sunlight is composed of six distinct colors: red, orange, yellow, green, blue, and violet. These terms are the names we use to characterize our perceptions of the different frequencies, or *wavelengths,* of the radiation that stimulates the receptors of our eyes. As you can see from Plate 1, colors we designate as shades of red have the longest wavelengths, and those we call violet have the shortest. This figure also shows the range of wavelengths that are not visible to humans. The wavelengths longer than those associated with the color red extend from infrared radiation to, at the longest extreme, radio waves. These wavelengths are not visible to us, nor are those that are shorter than the ones associated with the color violet. The nonvisible short wavelengths range from ultraviolet to cosmic radiation. Note also that different species are sensitive to different parts of the spectrum. Color vision has been discovered in a number of different classes of animals, including some species of cephalopod molluscs, fishes, amphibians, reptiles, birds, and certain mammals (particularly squirrels and primates). Generally, it has been observed that rodents other than squirrels seem to lack the ability to differentiate colors. Also, diurnal mammals generally appear to be much more adept at color discrimination than nocturnal animals (Dewsbury, 1978).

Hue, Saturation, and Brightness

Color is characterized in terms of *hue, saturation,* and *brightness,* three terms that describe the *experiential* aspects of three physical properties. **Hue** is the technical term that psychologists use to describe perceptions of the *chromatic* colors, that is, all of the visible wavelengths or wavelength combinations *excluding* those that result in perceptions of white, black, or neutral grays. **Saturation** refers to the perceived richness of a hue, and corresponds to the *purity* of a color. A pure color is one that has little or no white light mixed with a monochromatic wavelength. The purer the color physically, the more highly saturated it will be (see Plate 2). Color also can be described in terms of its **brightness,** the psychological term that relates to the physical property of luminance (intensity). The more energy radiated per unit of time from a luminous source, the brighter the source, or the brighter the object reflecting light from that source.

Color Mixture

If you are an artist of sorts, or remember back to those times as a child when you experimented with crayons and paints, you know that colors can be combined to produce new colors. For example, blue and yellow *pigments* mixed in the proper proportions produce a green hue. A hue produced from a combination of pigments is called a *subtractive* color mixture. In a blue-yellow combination, the blue pigment on a surface absorbs, in other words subtracts, primarily nonblue wavelengths (yellows, oranges, and reds) from white light. The yellow pigment subtracts primarily nonyellow wavelengths (blues and violets). The result is a subtractive mixture that looks green (Plate 3).

The other kind of color mixture is an *additive* mixture. In an additive mixture *wavelengths,* not pigments, are mixed. If we were to shine a green light and a red light onto a white surface, *yellow* light would appear where the green and red overlapped (Plate 4). This happens because when the surface reflects both wavelengths they *add* together. It is *additive* color mixtures that are most important in understanding color perception.

If white light entering a prism can be separated into distinct colors, it is reasonable to expect that these colors can be recombined to again form white light. In fact, this is precisely what will happen if a second prism is interposed between the prism in our earlier example and a dark surface; a beam of white light will be projected onto the surface. This is due to the *addition* of the spectral colors; white light is produced by combining all of the spectral colors. However, we have also seen that white light can be produced by combining only two colors. For any color there is a matching color which, when combined with the first, produces an achromatic (no color) perceptual experience — white or various shades of gray. These are called *complementary colors* (Plate 5). The principle of additive color mixture can be demonstrated by aiming two projectors at a screen so that their images overlap to form a single image. Projected complementary colors will tend to cancel each other out, resulting in a white spot of light (assuming that relatively bright monochromatic colors are projected).

Theories of Color Vision

The Component Theory The principle of additive mixture is important in understanding how it is that we perceive different colors. Only the combining of certain colors will result in an achromatic experience, as we have seen. Most other color combinations produce *chromatic* experiences of various kinds. The results of various combinations of wavelengths are quite predictable.

Colors that are opposite each other on the *color circle* are complementary colors. A combination of complementary colors results in an achromatic color experience (the center of the circle in Plate 5). The result of combining colors that are not complementary is a color experience that lies between those color points on the circle.

The vast majority of *variations* in color that humans can perceive can be produced by an additive mixture involving three different colors, providing their wavelengths are fairly widely spaced along the color spectrum. Our eyes have three types of cones, each responsive to wavelengths within a certain range, rather than many types of cones responsive to many wavelengths. Based upon light absorption of the different pigments in each type of cone, it appears that cones in the yellow-green set are most sensitive to wavelengths of about 560 nanometers, those in the green set respond maximally to wavelengths of about 530 nanometers, and cones in the violet set are most sensitive to wavelengths of about 420 nanometers (Mollon, 1982).

These are the basic elements of the **component theory of color vision,** a theory originally proposed by an English physicist and physician named Thomas Young in 1807. (You may already know that Young was instrumental in demonstrating the *wave* properties of light.) Young's component theory was further developed some fifty years later by Hermann von Helmholtz (1821–1894), probably the most important figure in the psychology of vision. The Young-Helmholtz component theory holds that the perception of color is due to the *addition* of sensations from the three different sets of receptors. In other words, in this theory color perception is a direct result of the combined activities of the three different sets of cones.

The Opponent Theory Originally proposed by the German physiologist Ewald Hering (1834–1918), the **opponent theory** holds that color vision mechanisms operate in an antagonistic fashion. According to this theory, there are three paired opposing color systems: a set of receptors sensitive to white and black, a set sensitive to red and green, and a set sensitive to yellow and blue. Within each system there are cells that respond to one color, such as red, but, when they do so, also inhibit response to the complementary color (in this case, green). According to Hering, our perceptions of different colors are a result of the various "mixtures" of receptor signals within and among the three color systems in response to light of various wavelengths.

Current knowledge indicates that both theories, component and opponent, have validity. It seems almost certain that the retina contains three sets of cones, as the component theory suggests, and that additive mixing of cone activity in response to different visible wavelengths takes place. However, neurophysiological studies of the visual system in rhesus monkeys (DeValois, 1965), whose color vision is nearly identical to that of humans, show that there is more to primate color vision (including that of humans) than this.

DeValois and his associates implanted a microelectrode near a single nerve cell in the monkeys' lateral geniculate nucleus, a place in the thalamus where optic nerve fibers synapse with nerve fibers projecting to higher centers in the occipital cortex of the brain. What DeValois found was that individual nerve cells in the lateral geniculate nucleus respond to light of various wavelengths in much the same way as described by the opponent theory, that is, in an antagonistic fashion. For example, it was found that a single nerve cell fired vigorously when red light (wavelength 633 nanometers) was presented to the eye of the monkey. As soon as the light went off, firing in this cell ceased. But this same nerve cell showed an *opposing* pattern of firing when a green light (wavelength 533 nanometers) was turned on. The cell was inhibited during the duration of green light, but increased its rate of firing when the light was turned off. Response patterns of this cell to intermediate wavelengths were characterized as correspondingly intermediate between the responses already described. DeValois also found nerve cells in the lateral geniculate area inhibited by red and excited by green, other cells excited by blue and inhibited by yellow, and still others excited by yellow and inhibited by blue. In addition, there was another class of cells that responded to all visible wavelengths, not differentiating among different wavelengths. Based on this and other evidence, it seems that *both* component and opponent processes are responsible for color vision in primates. The three classes of cones operate in an additive way, but these receptors synapse with other nerve cells that recode the cone inputs in an opponent manner for further processing in higher centers of the brain.

The Perception of Two-Dimensional Patterns

Much of what we know about the perception of form and pattern was contributed by the Gestalt psychologists. In Chapter 2 we saw that the Gestalt psychologists held that the whole is different from the sum of its parts. These psychologists opposed the idea that conscious experience could be understood by breaking it down into its component parts, including percepts and parts of percepts, such as images and sensations. The Gestalt psychologists argued that perception was surely more than a matter of experience reduced to individual sensory elements. For example, a figure such as a triangle continues to be perceived as a triangle regardless of the viewing angle and, therefore, the particular visual receptors stimulated. A melody is recognized as the same whether it is played in the key of C or F, although a different set of auditory receptors is stimulated in each key. Clearly it is the *configuration* or *pattern* of receptors stimulated, not the individual receptors themselves, that is responsible for our stable perceptions of figures or melodies. The Gestalt psychologists believed that the brain is biased innately, through natural selection, to respond to *patterns* of sensory stimulation, and they proposed several principles by which our percepts of two-dimensional forms are organized.

Principles of Perceptual Organization

Figure-Ground The most essential principle of perceptual organization is the **figure-ground** relationship, one we usually take completely for granted. Stated simply, some things stand out from surrounding stimuli, and these are called *figure;* the background stimuli are called *ground.* The figure-ground phenomenon is not restricted to the perception of two-dimensional patterns; it applies to three-dimensional visual perception and perceptions based on modalities other than vision as well. But the fact that it can be demonstrated with certain two-dimensional patterns strongly suggests that it is not produced by differences in stimuli, such as increased intensity or meaningfulness of the figure. Rather, it appears to be an organizing feature imposed by the perceptual system (Figure 12.1). To appreciate this you must realize that there is no *sensory* reason for the blotch—white middle portion of the illustration—to stand out and maintain its own contour, while the surrounding black area forms a background. Yet that is what most people see. In some cases figure-ground relationships are reversible, as you can see from an inspection of the illustration of the chalice/face (Figure 12.2). Weintraub and Walker (1966) summarize the important distinctions between figure and ground:

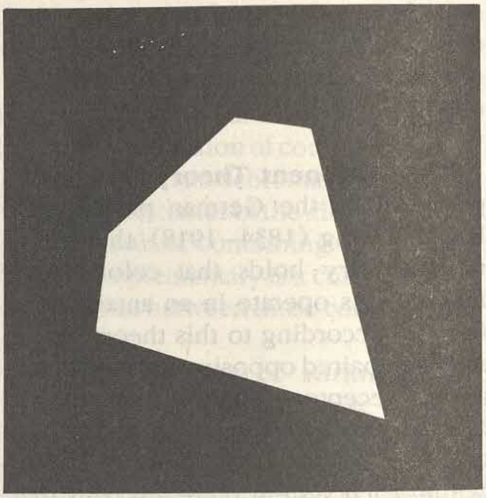
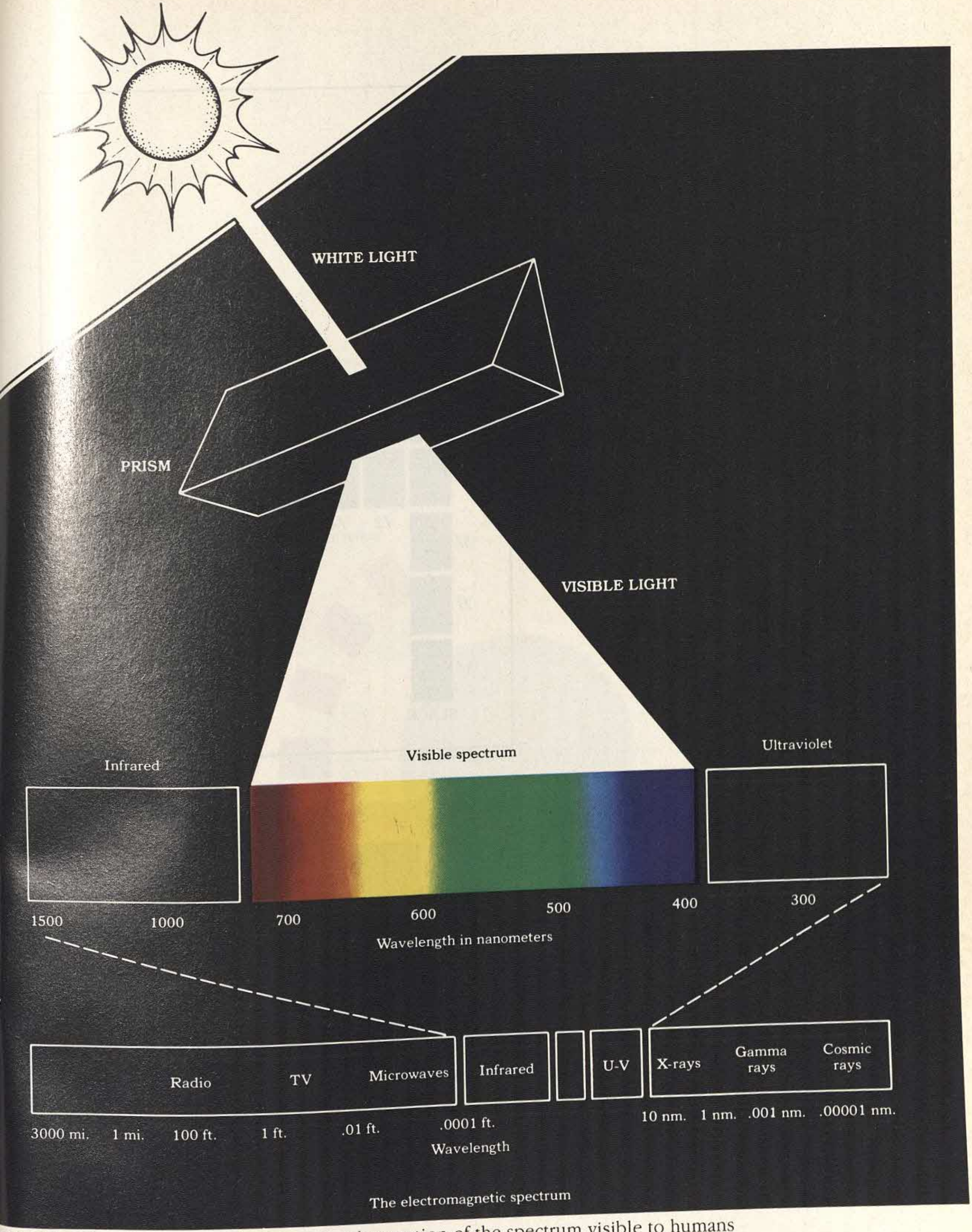


FIGURE 12.1 The Gestalt principle of figure-ground perception: The figure stands out from the dark background.

> (1) When two fields have a common border, it is the figure which seems to have shape while the ground does not.



LATE 1 The electromagnetic spectrum. That portion of the spectrum visible to humans anges from about 400 to 750 nanometers. One nanometer equals one billionth of a meter.

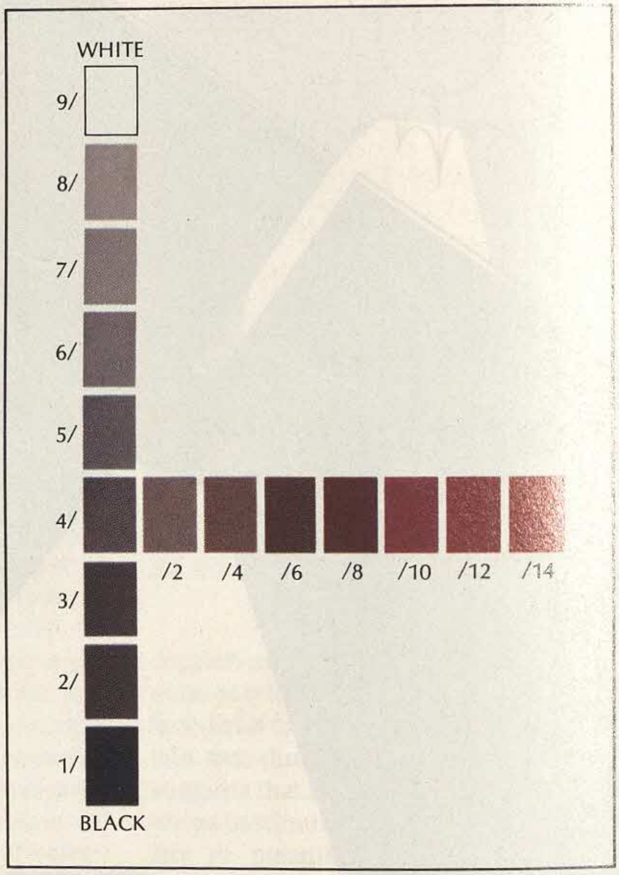


PLATE 2 Saturation and brightness. The vertical scale illustrates the concept of brightness, ranging from black to white. The horizontal scale illustrates the concept of saturation for a given hue, ranging from low (*left*) to high (*right*).

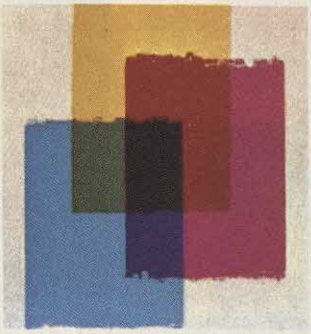


PLATE 3 Subtractive color mixture resulting from a mixture of *pigments* (see text p. 301 for explanation).

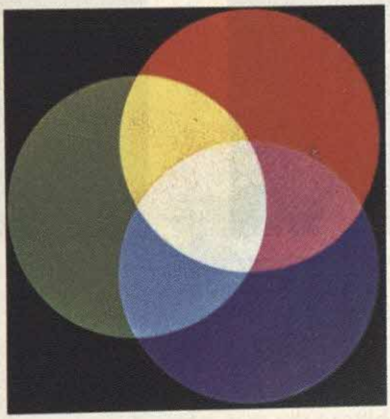


PLATE 4 Additive color mixture resulting from a mixture of *wavelengths* (see text p. 302 for explanation).

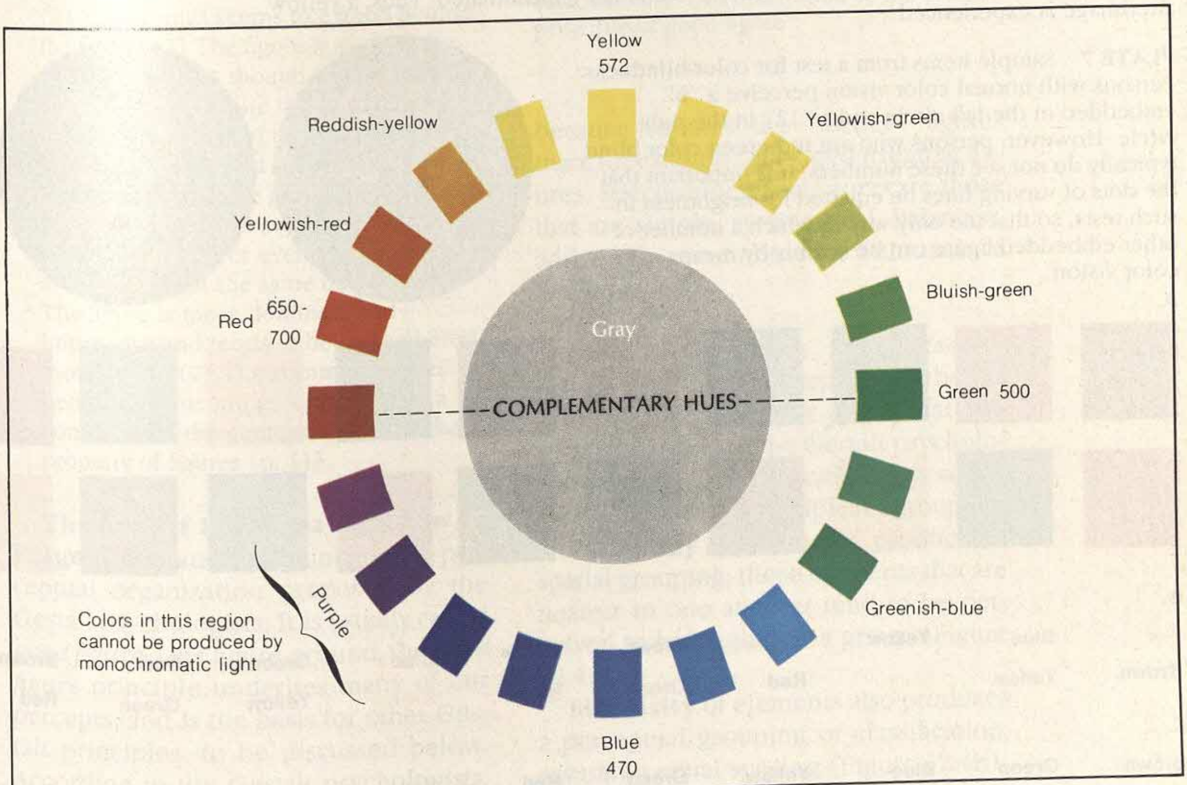


PLATE 5 Complementary colors. Colors opposite each other on the circle are called complementary colors (hues). When wavelengths associated with two complementary colors are mixed they produce an achromatic perceptual experience (white or various shades of gray). The numbers next to red, yellow, green, and blue specify the corresponding wavelengths of these colors.

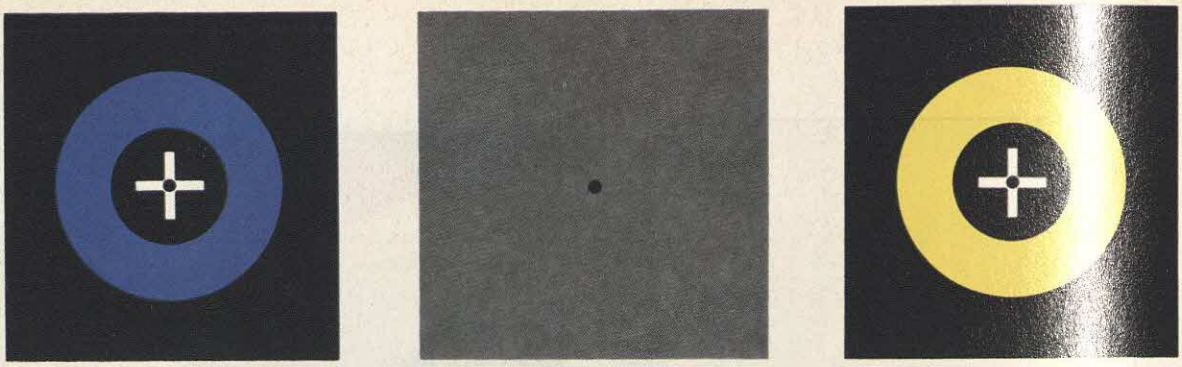


PLATE 6 Negative afterimage. Stare at the dot in the blue circle for a half minute; then look at the dot in the gray rectangle. You will experience a negative afterimage—the complementary color of the one you first stared at. A different afterimage results if you stare at the dot in the yellow circle and then look at the dot in the gray rectangle. What color will this afterimage be? Negative afterimages are consistent with the opponent theory of color vision. Some receptors in the yellow-blue set are excited as you stare at the blue circle. But once your gaze shifts to the gray rectangle, these cells are inhibited from firing, and the opponent system—cells excited by a yellow stimulus—is stimulated. Thus, a yellow afterimage is experienced.

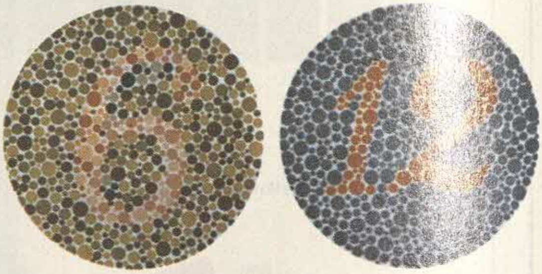
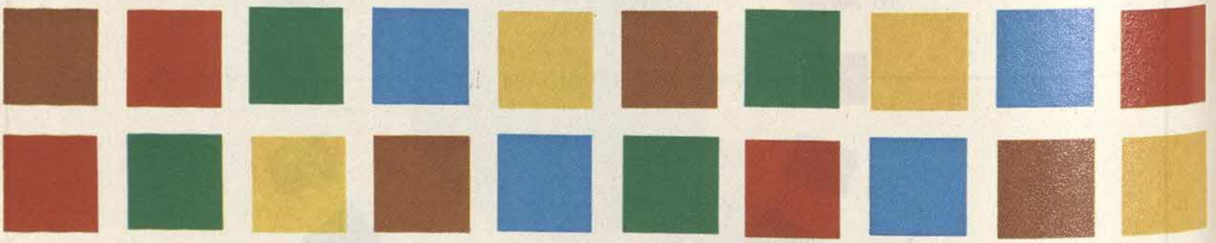
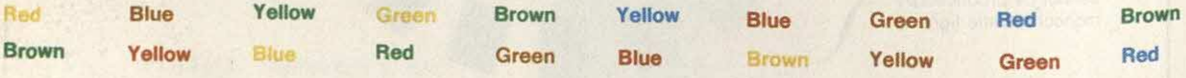


PLATE 7 Sample items from a test for color blindness. Persons with normal color vision perceive a "6" embedded in the left circle and a "12" in the right circle. However, persons who are red-green color blind typically do not see these numbers. It is important that the dots of varying hues be equated for brightness in such tests, so that the only way in which a number or other embedded figure can be seen is by means of color vision.

A.



B.



Red	Blue	Yellow	Green	Brown	Yellow	Blue	Green	Red	Brown
Brown	Yellow	Blue	Red	Green	Blue	Brown	Yellow	Green	Red

C.

Brown	Green	Blue	Yellow	Green	Red	Yellow	Green	Blue	Brown
Blue	Yellow	Brown	Green	Red	Brown	Green	Red	Yellow	Blue

PLATE 8 The Stroop effect. Name the colors in A as fast as you can and record your time. Then name the colors of the words in B as fast as you can and record your time. Finally, read the words in C as fast as possible and time yourself. People usually take longer—and find it harder—to name the colors in B compared to A, or to do the task in C. This phenomenon—the Stroop effect (Stroop, 1935)—illustrates how perceptual identification relies on memory. The effect shows that we routinely inject meaning into our perceptions and that we have little control over the process. In B, the colors inject meanings that conflict with the meanings elicited by the words—no matter how hard we try to ignore the words' meanings.

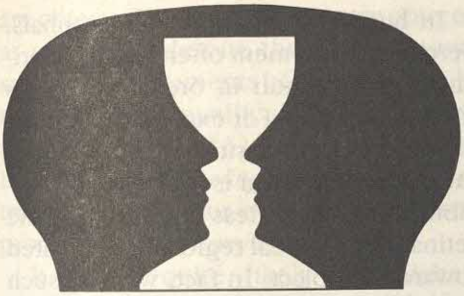


FIGURE 12.2 Example of reversible figure-ground. The figure may appear to represent either a chalice or two faces in profile.

> (2) The ground seems to extend behind the figure. (3) The figure appears to be object-like (even though it may be an abstract shape) while the ground does not. (4) The color of the figure seems more substantial and solid than that of the ground. (5) The ground tends to be perceived as farther away and the figure nearer the observer even though both are obviously at the same distance. (6) The figure is more dominant and impressive and tends to be remembered more easily. (7) The common border between figure and ground is called a contour, and the contour appears to be a property of figures (p. 11).

The Law of Prägnanz The **Law of Prägnanz** is another principle of perceptual organization proposed by the Gestalt psychologists. It is usually called *good figure.* Like figure-ground, the *good figure* principle underlies many of our percepts, and is the basis for other Gestalt principles, to be discussed below. According to the Gestalt psychologists, our percepts are organized so that forms or patterns appear in as simple and orderly a way as possible. The forms in Figure 12.3 could be perceived as three irregular figures, but you probably see them as two overlapping squares. The Gestalt psychologists argued that this is because squares are "better" figures than, for example, six-sided irregular figures. Specifically, *good figures* are those that are simple, symmetrical, balanced, and easily remembered (Weintraub & Walker, 1966).

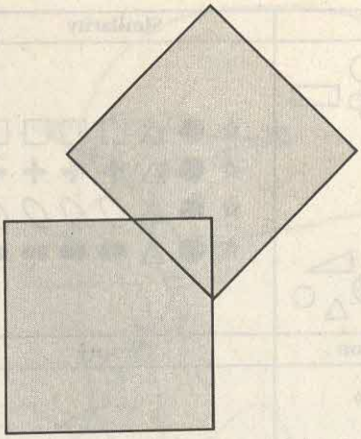


FIGURE 12.3 An illustration of the Gestalt principle of good figure.

Laws of Grouping Elements of a pattern tend to be grouped together in systematic ways by our perceptual systems, according to the Gestalt psychologists. Figure 12.4 illustrates a few of the more compelling principles of grouping:

Proximity of elements produces a spatial grouping; those elements that are nearest to one another tend to be perceived as belonging to a group (Figure 12.4a).

Similarity of elements also produces a perceptual grouping or classification, assuming equal spacing (Figure 12.4b).

Good continuation refers to the observation that elements that continue the *direction* of other elements in a figure tend to be grouped together perceptually (Figure 12.4c).

Closure refers to the tendency to perceptually fill in missing parts of a pattern.

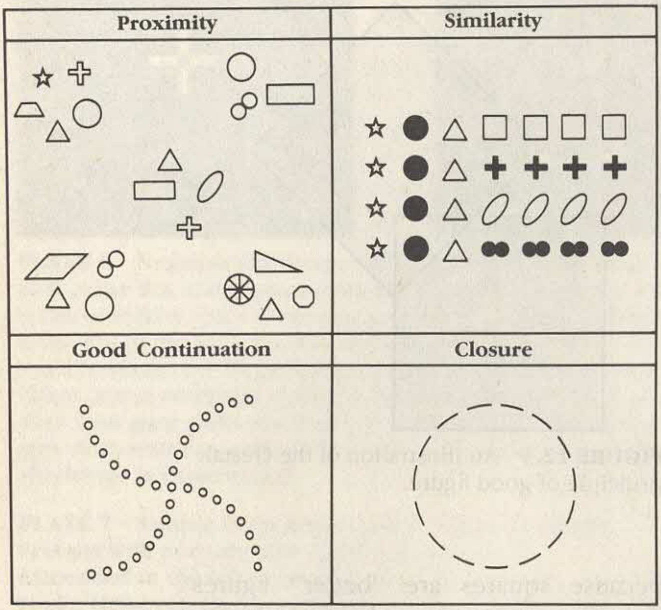


FIGURE 12.4 Illustration of Gestalt laws of grouping in perception.

When presented with a partial pattern in Figure 12.4d, we tend to see it as a *complete* figure.

The Perception of Movement

Motion is an integral part of our universe, our planet, the stimuli in our immediate environment, and ourselves. It should be obvious that the accurate detection of visual movement is crucial to any species that locomotes and processes the environment visually. It should therefore not be surprising that many animals are quite adept at perceiving visual movement, especially insects, amphibians, birds, and mammals. Movement detection is especially acute in most species of predaceous birds that must make accurate split-second decisions in order to capture moving prey.

In humans and many other animals, perceived movement often results in orientation to stimuli in order to process them more fully. For example, the edge of the retina is sensitive only to movement; the object that is moving is impossible to identify unless other parts of the retina (in the foveal region) are oriented toward the object. In fact, without such orientation the object will not even be noticed unless it is moving. The very extreme edge of the retina is also sensitive to movement, but in this region activation of cells by a moving stimulus will not even result in perception of the stimulus. However, the activation does initiate a reflex that rotates the eye so that the object can be seen and identified (Gregory, 1972).

How Is Movement Perceived?

Explaining the visual perception of movement would be relatively easy if all we were faced with was a stimulus moving across the visual field of a *stationary* eye. As the stimulus moves, light reflected from it excites adjacent sets of visual receptors, yielding a perceptual experience of motion. As it turns out, things are not so simple, even in this very elementary situation. Recordings of the activity of individual neurons in the visual (occipital) cortex of cats and monkeys indicate that certain cells are geared to respond selectively to various kinds of movements. In other words, our perception of movement when a stimulus crosses the visual field of a stationary eye is due not only to the "on-off" firing of adjacent receptors in the eye itself, but also to the activity of special cells further along the visual pathways.

In the real world our eyes are never perfectly stationary. They are constantly moving, even when focusing on stationary objects. Yet we see stationary objects as unmoving despite the constant tiny, sweeping movements of our eye, which result in continually changing retinal images (Figure 12.5). And we see moving objects as moving even though we track them with our eyes and, therefore, produce a *stationary* retinal image.

It seems quite likely that higher centers in the brain are responsible for keeping our perceptions of movement or stability in line with the actual happenings in the environment. It has been hypothesized that the brain compares information communicated to and received from the eye muscles with information received from the retina of the eye. If the retinal image is moving but the eyes are also moving, then the brain decides that the object being fixated is stationary. If the retinal image is stationary but the eyes are moving, then the brain concludes that the object is actually moving.

Can the brain be deceived in its decision-making concerning movement? Apparently it can. If you close one eye, look at this page, and then gently push at the side of your open eye, you will experience movement of the page. What may be happening in this case is that the brain, deprived of *normal* eye movement feedback from the muscles controlling the eye, processes a moving retinal image. But without the self-initiated eye movements necessary for informing the brain that the eyes are scanning, the brain's decision is that the object in view is moving.

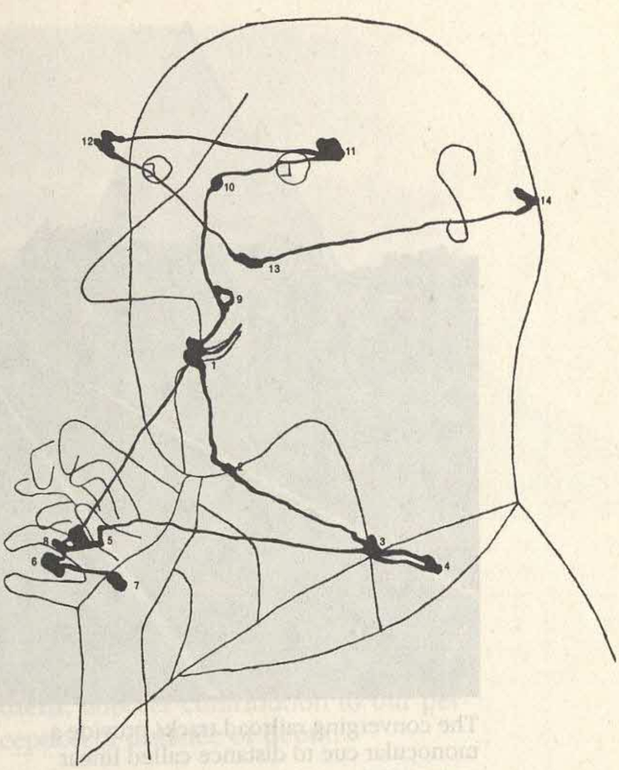
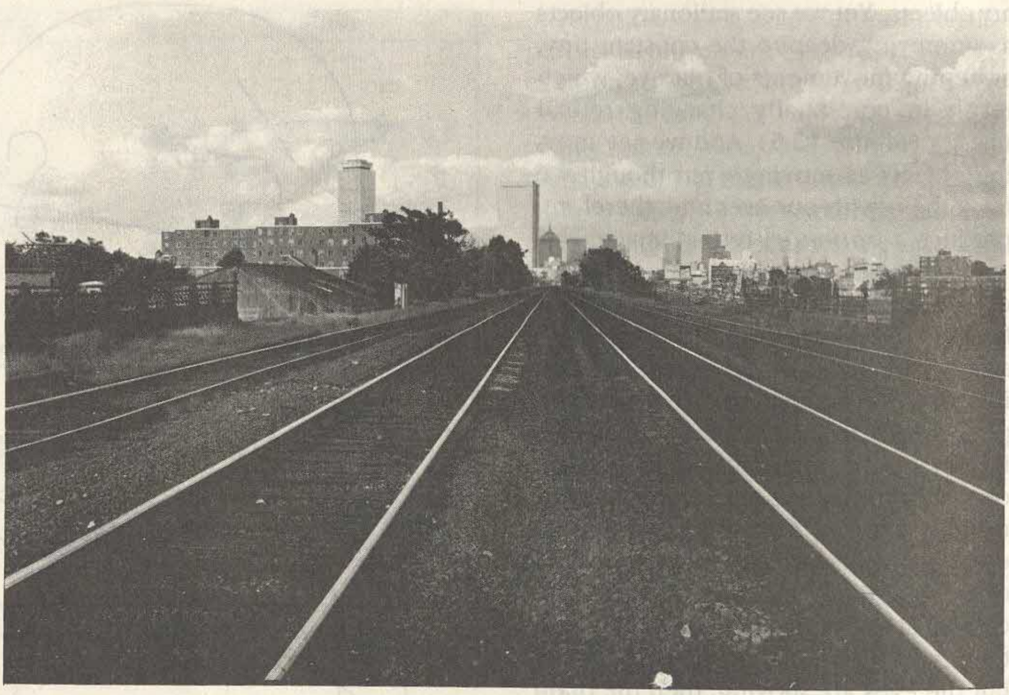


FIGURE 12.5 Our eyes are constantly moving, even when viewing a stationary object, yet the object is perceived as unmoving. The illustration shows the pattern of eye movements made by a subject during part of a 20-second viewing of this drawing adapted from Paul Klee's "Old Man Figuring." The numbers indicate the order of the subject's visual fixations, and lines between them represent saccades —rapid movements of the eyes.

The Perception of Depth

Many people believe that the ability to perceive the third dimension, depth, is basically a matter of having two eyes. However, although binocular vision can provide us with important information about depth or distance, it is not essential. There are several cues, called **monocular cues,** that even one-eyed individuals can utilize to experience depth in their perceptions. Of course these cues influence depth perception in two-eyed persons as well, but it is not essential to have sight in both eyes in order to take advantage of the information the monocular cues provide.



The converging railroad tracks provide a monocular cue to distance called linear perspective.

Monocular Cues

Perceived Size Generally, the further away an object is from our eyes, the smaller it looks. There is good reason for this, since the size of the image cast on the retina of the eye varies directly with the object's distance from the eye. Of course, our perception of the size of an object depends upon more than the size of the retinal image. If you look at a coffee cup placed sixty centimeters away, it appears smaller than the same cup at a distance of thirty centimeters, although not 50 percent smaller. We retain a certain amount of size constancy in our perception of the coffee cup, regardless of the change in distance. We will discuss size constancy later in the chapter. For now, it is enough to know that *apparent* size of an object does vary somewhat with distance, and therefore can tell us something about the object's distance from us.

Linear Perspective Anyone who has ever seen a long, straight section of railroad tracks in a photograph or painting cannot help but be struck by the illusion of depth created by the converging rails. In the world of three dimensions the rails are of course parallel, but they *appear* to get closer together as a function of increasing distance. Artists capitalize on this illusion by painting the rails so that they angle toward one another on the flat surface of the canvas.

Atmospheric Conditions Another monocular cue for perceiving depth or distance involves conditions in the atmosphere. Under normal conditions, objects that are far away appear less distinct and relatively blurred compared to closer objects. Because of this, atmospheric conditions such as fog, dust, or smoke in the air that naturally tend to blur objects can distort our perception of the distance of those objects. You can probably think of several examples that illustrate the influence of atmospheric conditions on perception of distance. One that comes readily to the authors' minds involves the perception of Mount Rainier, the most glaciated and easily one of the most impressive mountain peaks in the continental United States. Mount Rainier rises over fourteen thousand feet and is situated approximately fifty miles southeast of the city of Seattle in the state of Washington. On a clear day it forms a magnificent backdrop to the city. For example, when conditions are hazy visitors to Seattle typically estimate Mount Rainier to be much further away than they do when the weather is clear.

Interposition When two or more objects are in approximately the same line of vision, the closer ones tend to partially obscure the ones further away (Figure 12.6). Like linear perspective, **interposition** is a cue that artists often use to create an illusion of depth or distance.

Texture Gradients Surfaces of objects that are nearer tend to be more detailed in terms of contour, contrast, and complexity than surfaces further away. Imagine that you are standing on the ten-yard line of an American or Canadian football field with natural turf. Sections of field within a yard or two of where you stand can be seen in considerable detail. You can see individual blades of grass, slight irregularities in the contour of the turf, and areas that have cleat marks. As you extend your gaze further up the field, to the fifteen-, twenty-, and twenty-five yard lines, the details of the playing surface are more difficult to see. This systematic loss of detail with increasing distance is referred to as a **texture gradient,** another contribution to our perception of distance or depth.

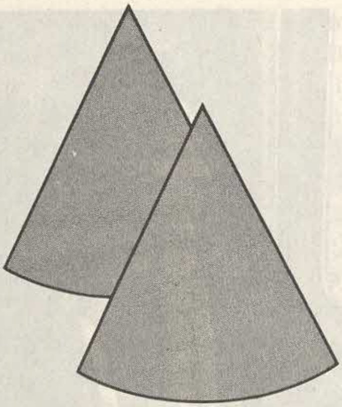


FIGURE 12.6 Interposition. An object that partially occludes another is generally perceived to be closer than the occluded object.

Shadows Shadows can create a perceptual experience of depth. Shadowing effects, like other monocular cues, can be used by artists to createé a dramatic illusion of three-dimensionality.

Brightness and Saturation of Colors Objects that are close generally appear brighter than when they are further away. In addition, the hues associated with the object will appear more highly saturated when the object is close, and less so when it is further away.

Motion Most of the monocular cues for perceiving depth mentioned so far probably are obvious to you. A cue that may be less obvious involves the motion of objects. There are actually two aspects of motion, *rate* and *direction,* that can provide the observer with information about the relative distance of an object.

Objects close to a moving observer are seen as moving in a direction opposite the observer's. Objects at further distances appear to be relatively stationary, or moving in the same direction as the observer. These differences in perceived direction of movement are part of a monocular cue to distance called motion parallax.

The cue provided by *rate* of motion is that the closer an object is to a moving observer, the faster *it* seems to move across the visual field. As for *direction:* when great distances are involved, closer objects are perceived as moving in the direction *opposite* to the direction of movement of the observer; objects further away are perceived either as relatively stationary, or as moving in the *same* direction as the movement of the observer.

Imagine you are a passenger with a window seat on a train traveling at a high rate of speed through the countryside. As you enjoy the view, you can see that objects near the track, such as rocks and bushes, appear to be moving rapidly away from you. But when you look out toward the horizon, the distant hills and mountains seem to be moving slowly in the same direction as the train. Suppose a farmhouse and outbuildings are situated at an intermediate distance. Momentarily you may experience these objects as stationary compared to those very near or very far away. Motion cues such as these can provide a wealth of information about relative distance.

Accommodation As we noted in Chapter 11, **visual accommodation** refers to the automatic adjustment of the lens of the eye that allows us to see objects at various distances in focus. When we are visually fixating objects that are close to us, the lens tends to bulge. The degree of convexity of the lens is reduced when we fixate objects that are further away. The cues for distance that the act of accommodation provides are thought to arise from the actions of the *ciliary muscles.* When these muscles contract, they release tension on the lens, causing it to increase its curvature. The contraction and expansion of these muscles could provide different kinds of feedback via the kinesthetic receptors, and thus cue us as to changes in the distance of an object.

Binocular Cues

As we have seen, there are many sources of information about depth or distance that do not depend on binocular vision. However, there are two additional cues that are a result of the coordinated action of both eyes: *convergence* and *retinal disparity.*

Convergence The term **convergence** refers to the coordinated movements of the two eyes that allow an image of an object to be cast on retinal areas. Specifically, when an object is nearer than about twenty meters the two eyes must turn toward one another in order to fixate the object. The closer the object, the greater the degree of convergence. It is thought that the muscles that control convergence transmit messages related to the amount of tension involved in turning the eyes. Such information could serve as a kinesthetic cue to distance, although there is some controversy over this hypothesis.

Retinal Disparity The term **retinal disparity** refers to the slightly disparate images that are cast on each retina. The closer an object is to an observer who is fixating that object, the greater is the disparity between the two retinal images of the object. You probably first became aware of this as a child. But in the event that you don't recall the experience, try this simple demonstration. Hold a pencil at arm's length and look at it. Then close the right eye while continuing to look at it with the left. Now reverse the procedure by closing the left eye and staring at the pencil with your right eye. Most likely, you will be able to notice a difference in the "picture" each eye receives. Now hold the pencil about six inches away and repeat the process. This time the difference between the two images of the pencil will be much more pronounced. Retinal disparity turns out to be a very powerful cue for perceiving depth or distance.

The Developmental Origins of Perception

To what extent are our perceptions programmed innately, and what is the role of experience in structuring our perceptions? These questions were originally posed by philosophers, and attempts to answer them resulted in the controversial nature-nuture debate. The British empiricists, including John Locke (1632–1704), Thomas Hobbes (1588–1679), and George Berkeley (1685–1753), believed that perceptions arise totally from sensory experience. In fact, Locke argued that the mind of the newborn is a complete blank, a *tabula rasa.* In their view perceptions, and all knowledge, come about from our experience in sensing the environment. The ideas of the British empiricist philosophers crystallized as the *nurture* side of the controversy. These precursors of behaviorism in psychology did not go unchallenged, however. During the eighteenth century the *nature* side of the argument was formalized, especially by the German philosopher Immanuel Kant (1724–1804). Kant argued that our percepts have an innate basis; in other words, that sensory experience is not sufficient to account for the ways our percepts are organized.

The nature-nurture debate about perception was taken up during the first half of the twentieth century by psychologists. You will recall from Chapter 2 that the Gestalt psychologists hypothesized that our perceptions are organized according to innate principles. We described some of these principles earlier in this chapter, in our discussion of the perception of two-dimensional patterns. Psychologists in the empiricist tradition, mainly the early functionalist and behaviorist psychologists, argued that learning played the predominant role in making our percepts what they are. Today there is much less controversy over the developmental origins of perception. In part, this is because we now have rather strong evidence that *both* experiential and innate factors are responsible for the development and elaboration of our perceptions.

Perception and Experience

We have already discussed the most convincing evidence for the importance of experience in influencing perception in Chapter 6. Recall that kittens and chimpanzees experimentally deprived of visual experience, either totally or in part, developed visual perceptual deficits. And it goes deeper than this: visual perceptual deprivation can result in abnormal responsiveness of neurons in the visual cortex of the brain. We also mentioned in that chapter the fact that humans who have been visually impaired from birth by cataracts continue to manifest perceptual deficiencies even after their sight is later restored through surgery.

There is additional evidence regarding the importance of experience in perception that is not associated with deprivation. Demonstration of certain *constancies* in our perceptions, in spite of substantial variation in sensory input, highlights the role of experience in influencing perception.

Size constancy can be demonstrated by looking into a mirror. Usually, the reflected image is perceived as being the same size as the observer's face. However, as measurement will ascertain, the reflected face is smaller than the face of the observer.

Size Constancy In our discussion of depth perception we saw that the apparent size of an object can serve as a cue to the perception of that object's distance. The size of the image of an object cast on the retina of each eye varies directly with the distance of the object from the eye. And yet even though the sensory information may change significantly as a function of distance, most of the time we do not perceive significant changes in the size of an object that is familiar to us.

For example, a friend of yours who is standing thirty feet away from you in a classroom does not appear one-tenth as tall as when standing only three feet away. This is a demonstration of **size constancy.** It appears that learning is at least partly responsible for this phenomenon. The crucial element to this learning is experiencing size and distance relationships.

A delightful illustration of how important experience is to the development of size constancy is contained in anthropologist Colin Turnbull's classic account of the BaMbuti Pygmies of Zaire (formerly the Congo). On one occasion Turnbull took one of the Pygmies, Kenge, to the top of one of the foothills of a mountain range forming part of the eastern border of Zaire. This was Kenge's first venture beyond the confines of the dense forest that was home to the BaMbuti, and it was filled with surprises.

> When Kenge topped the rise, he stopped dead. . . . Down below us, on the far side of the hill, stretched mile after mile of rolling grasslands, a lush, fresh green, with an occasional shrub or tree standing out like a sentinel into a sky that had suddenly become brilliantly clear.

> . . . On the plains, animals were grazing everywhere—a small herd of elephant to the left, about twenty antelopes staring curiously at us from straight ahead, and down to the right a gigantic herd of about a hundred and fifty buffalo. But Kenge did not seem to see them.
>
> . . . Then he saw the buffalo, still grazing lazily several miles away, far down below. He turned to me and said, "What insects are those?"
>
> At first I hardly understood; then I realized that in the forest the range of vision is so limited that there is no great need to make an automatic allowance for distance when judging size. Out here in the plains, however, Kenge was looking for the first time over apparently unending miles of unfamiliar grasslands, with not a tree worth the name to give him any basis for comparison (1961, pp. 251–252).

Turnbull attributed Kenge's lack of size constancy to his unfamiliarity with seeing things at any great distance. Someone might counter that perhaps Kenge simply had never seen buffalo or other game at any distance, great or small. But this was not the case: the BaMbuti's native forests contain buffalo, although of a different species, which Kenge had seen before.

Some investigators have argued that size constancy may be achieved without learning to *compensate* for changes in the distance of objects (Gibson, 1950). The idea is that not only does the retinal image size of an object decrease with increasing distance, but so also does the retinal image size of the object's background. Suppose a girl is standing five feet away from you on a sandy beach, and her identical twin is standing twenty feet away, at the water's edge. The retinal image size of the twin further away is one-fourth that of the closer twin. But this relationship also holds for the stimuli near each twin, such as rocks, logs, other people, and so on. Thus the *ratio* of the retinal image size of an object to image size of background stimuli will be the same *regardless of distance*, and this may account for size constancy. According to this explanation people do not have to correct for distance in order to achieve size constancy; they simply recognize the invariant nature of the object : background stimuli ratio. Whichever explanation is correct, there is little doubt that some experience with size-distance relationships is necessary.

Turnbull's description of Kenge's lack of size constancy is a case in point. Kenge's experience with buffalo had always involved short distances. Kenge perceived the buffalo as insects, apparently because he had little experience in viewing animals or anything else at great distances. However, most of us have had such experiences, and tend to perceive the actual, rather than retinal, size of an object. But sometimes this ability can create perceptual difficulties in the form of illusions.

An illusion that is quite common and demonstrates the perceptual system's attempt to compensate for distance is the *moon illusion*. The moon appears approximately one and a half times larger when it is near the horizon than it does when it has risen to a high point in the sky. The reason for this apparently has little to do with differences in light refraction, as is often supposed. Rather, it appears that the horizon provides cues for distance that are not present when the moon is not close to the horizon (Kaufman & Rock, 1962). One hypothesis is that the moon is experienced as further away when near the horizon, and so the perceptual system compensates by increasing its size in order to maintain size constancy. Fortunately for the romantics among us, the perceptual system appears to *overcompensate,* providing us with a larger-than-life experience of the moon near the horizon.

Finally, there is evidence that size constancy in children increases systematically between the ages of about two and eleven (Wohlwill, 1960). A gradual developmental increase in size constancy seems quite consistent with the notion that experience with size and distance is important in establishing this perceptual phenomenon.

A final argument for the importance of experience in structuring perception involves the *adaptability* of the perceptual system. A very dramatic instance of perceptual adaptation can be observed when individuals wear prisms over their eyes that distort the visual environment. The first reported prism experiments were carried out by Stratton (1896, 1897) in the late nineteenth century (Gregory, 1972). Stratton wore prisms that inverted and mirror-imaged the visual environment. His initial reactions to this distortion were confusion and, of course, a great deal of difficulty in everyday navigation. What is remarkable, however, is that Stratton, and others who have tried this bizarre experiment since, adjusted to the upside-down-and-backward world within a week or so of first putting on the prisms. Interestingly, after a successful adjustment to the prisms had been made, removal of the lenses also caused confusion and motor problems, which were, however, soon overcome. The adjustments that make successful locomotion and other motor behaviors possible are probably at the motor, not the visual-perceptual, level. In other words, Stratton did not finally come to see his artificially induced upside-down world as right side up. Rather, Stratton continued to realize that his perceptual world was altered, but was able to compensate for this state of affairs. However, induced distortions of a less dramatic nature—such as displacements of objects to the right or left of their actual locations—are eventually perceived as normal.

Visual-motor accommodations to distorted visual environments suggest that the visual motor system is highly adaptable. In view of this adaptability, it is not unreasonable to suspect that perceptual-motor adjustments to the environment may in part underlie the development of many perceptual processes. For example, Held and Hein (1963) have presented convincing evidence that active movements in visual-spatial environments are necessary for kittens to develop normal visual perceptual abilities. Kittens prevented from walking about in a compartment, but not from seeing the visual stimuli in the compartment, performed poorly on tasks measuring ability to perceive depth.

Early Perceptual Abilities

Certain perceptual abilities are present so early in life that it is difficult to rule out some kind of innate basis for their development. In Chapter 6 we noted that newborns (1) react to changes in brightness, form, movement, and color; (2) scan the edges and angles of objects; (3) show preferences for relatively complex and social stimuli; (4) react to many of the characteristics of sounds in much the same way as adults do; and (5) seem especially tuned in to certain distinguishing features of human speech. Newborns show evidence of these sensitivities with little or no learning, suggesting that the establishment of these perceptual capacities is brought about through physical maturation operating according to precise genetic instructions.

There is another perceptual capacity — for perceiving depth — that may also have an innate basis, although there have been no demonstrations of depth perception in newborns. We will now reexamine the topic of depth perception, with special emphasis on research concerned with its developmental origins.

Depth Perception The classic studies of depth perception in immature organisms were carried out by Eleanor Gibson and Richard Walk (Gibson & Walk, 1960; Walk, 1966). They are often referred to as the "visual cliff" studies because of the apparatus used for assessing depth perception. The visual cliff apparatus in the original studies consisted of a piece of heavy glass that formed a sort of transparent table top (Figure 12.7). The glass top is held up by supports and a centerboard bisects the rectangular top. On one side of the centerboard, a piece of wallpaper with a checkerboard design is placed flush against the underside of the glass. This side is called the "shallow" side, because it appears to be solid when viewed from above. On the other side of the centerboard — the "deep" side — the same wallpaper material is placed on the floor, a few feet from the glass top, thus forming the visual cliff.

In the typical visual cliff experiment, a subject is placed on the centerboard and the experimenter records on which side, shallow or deep, the subject spends most of its time. Gibson and Walk performed several such experiments with a variety of species. In nearly every instance subjects preferred the shallow side, suggesting an ability to discriminate depth. What is most interesting are experiments involving animals that can move about on the first day of life, including domestic chicks, baby goats, and lambs. When these animals were tested on day one, all preferred the shallow side of the apparatus, suggesting that the ability to perceive depth may be innate.

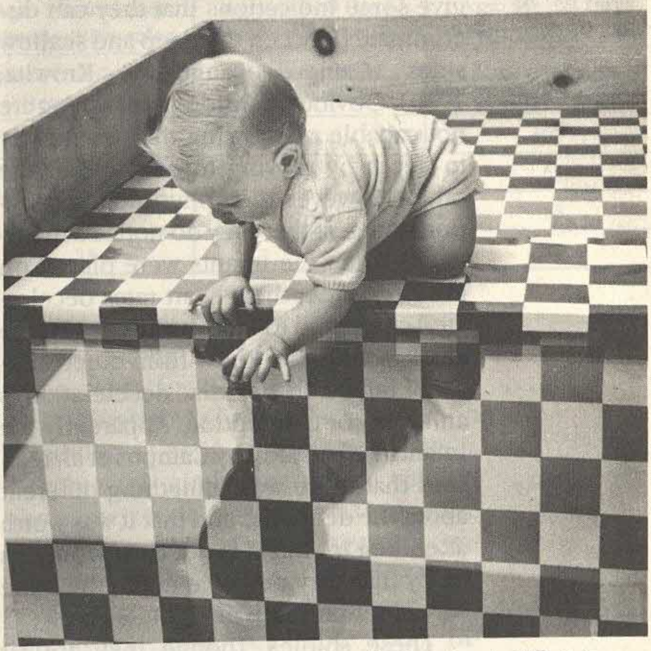


FIGURE 12.7 This apparatus is called a visual cliff. It is used to test for the presence of depth perception.

Six-month-old children also preferred the shallow side of the apparatus. However, it is difficult to conclude from this that human depth perception is innate. Six months is sufficient time for a good deal of perceptual learning to take place.

Why not test infants younger than six months on the cliff? The problem is simply that most infants younger than six months cannot crawl well enough to show a clear discrimination between the deep and shallow sides of the visual cliff apparatus. However, researchers have found that children as young as six weeks give some indications that they can discriminate between the deep and shallow sides (Campos, Langer, & Krowitz, 1970). Obviously children this young are not capable of showing their sensitivity to depth by moving to one side or the other. However, their physiological reactions suggest that they do notice a difference. When the infants were placed on the deep side, their heart rates decelerated compared to their heart rates on the shallow side. We know from other studies of infants that cardiac deceleration is an indicator of attention. Apparently the infants in the study by Campos et al. realized that there was something different about the deep side and that it was worth attending to. But it is not clear from this study that they perceive depth the same way older children and adults do.

These studies, though they are far from definitive, certainly suggest that even human depth perception has an innate basis. This idea was proposed by psychologists and philosophers alike long before the visual cliff studies, but these studies offered the first empirical support for what was once theoretical speculation. And other research findings derived from very different experimental procedures are consistent with the visual cliff results.

In a series of ingenious studies, T. G. R. Bower found that infants as young as six weeks respond as if they can perceive depth. Bower (1964, 1965, 1966) conditioned infants to make head-turning responses while looking at a cube thirty centimeters on a side at a distance of one meter. This was accomplished by reinforcing the child for head turns only when the cube was displayed. Head turns were not reinforced when the cube was not present. (The reinforcement consisted of the experimenter playing peek-a-boo with the infant after each appropriate head turn.) This is a simple matter of *instrumental discrimination learning* (see Chapter 8), in which the cube is the discriminative stimulus (S^D) and each head turn is an instrumental response.

Once the training phase of the experiment was completed, and infants were reliably responding more often to the cube than to no cube, a testing phase was initiated. During the testing phase the infant subjects were presented with four different experimental conditions (Table 12.1). In condition A the infants

TABLE 12.1 Different Conditions of Bower's Experiments with Infants on Distance Perception and Size Constancy.

Condition	Actual Size of Cube	Distance of Cube from Infant	Relation of Size of Test Cube to Size of Training Cube	Relation of Distance of Test Cube to Distance of Training Cube	Relation of Size of Retinal Image of Test Cube to Size of Retinal Image of Training Cube
Training	30 cm	1 m	—	—	—
Testing A	30 cm	1 m	same	same	same
Testing B	30 cm	3 m	same	three times the distance	one third the size
Testing C	90 cm	1 m	three times as large	same	three times the size
Testing D	90 cm	3 m	three times as large	three times the distance	same

TABLE 12.2 Results of Bower's Experiments with Infants on Distance Perception and Size Constancy.

			Age: 70–85 Days Viewing: Binocular	Age: 40–60 Days Viewing: Binocular	Age: 40–60 Days Viewing: Monocular
Test Condition	**Actual Size of Cube**	**Distance of Cube from Infant**	**Mean Number of Head Turns**	**Mean Number of Head Turns**	**Mean Number of Head Turns**
A	30 cm	1 m	103	98	101
B	30 cm	3 m	66	58	60
C	90 cm	1 m	54	54	53
D	90 cm	3 m	23	22	22

saw exactly what they had seen during the training phase—a thirty-centimeter cube at a distance of one meter. Condition B consisted of the thirty-centimeter cube at a distance of three meters. In condition C the infants were presented with a ninety-centimeter cube at one meter. And in condition D the infants saw the ninety-centimeter cube at a distance of three meters. These conditions were presented in different sequences so as not to confound the experimental conditions with carry-over effects, and the number of head turns under each condition was recorded. No reinforcement was given during the testing phase.

This experiment is really one involving *stimulus generalization.* Bower wanted to know what the infant had learned from the training phase of the study. Had the infants "coded" the distance of the cube, or were they simply associating a retinal image of the cube with reinforcement? The test conditions A, B, C, and D provided a means of answering these questions. Individuals generalize their conditioned responses to stimuli that bear a resemblance to those present during conditioning. Thus during the testing phase Bower's infants would be expected to show strong generalization to condition A, since it is identical with the training stimulus. But what about the other conditions? If the infants cannot perceive depth, but are simply coding the retinal image of the cube, then they should show as much generalization (as many head turns) in condition D as in condition A. This is because the ninety-centimeter cube at three meters in condition D casts the same size retinal image as the thirty-centimeter cube at one meter in condition A.

But these results were *not* obtained in the testing phase (see Table 12.2). Infants showed the *least* generalization in condition D, and less in B and C than in A. This pattern of findings suggests that the infants know that something is different about the thirty-centimeter cube at three meters (condition B)—the same cube size as in training but at three times the distance. Are they responding less in this condition because they are aware of the change in distance, or simply because they note a decrease in the size of the retinal image of the cube?

The reason appears to be related to distance, not retinal image size. The infants showed the least amount of responding when retinal image size was the same as in training, but distance and *actual* size of the cube were not (condition D). This suggests that infants know something about the *real* size of the cube and are not basing their responses exclusively on the sensory properties of the retinal image. We know this because the infants also responded less in condition C, where distance was the same as in training but cube size was three times larger. The same pattern of results holds for infants of two other age groups, and for infants with one eye patched (that is, under monocular viewing conditions).

Other studies (Bower, Broughton, & Moore, 1970; Yonas, Bechtold, Frankel, Gordon, McRoberts, Norcia, & Sternfels, 1977) report that infants four months of age, and perhaps as young as one to two weeks of age, responded to a large object approaching at a slow velocity with a characteristic defensive reaction: the eyes widen, the head retracts, and the arms are interposed between the object and the face. This kind of reaction can also be elicited by a projected image of an object that expands in size but does not vary in distance. However, the defensive reaction to expanding size is weaker than it is for a real looming object.

Retinal image size can be equated for two objects of different size by varying how close they actually approach the infant. In this case infants are more likely to show defensive reactions to the object that actually comes closest to them, even though its retinal image size is no larger than a bigger object further away. This finding and those from other related experiments raise the possibility that infants are responding to changes in distance, not just to retinal image properties or to other characteristics correlated with changes in distance. Taken together, the findings from the visual cliff studies, Bower's research, and other investigations (for example, Yonas, Peterson, & Lockman 1979) suggest that responsivity to depth is present quite early in life, at least by six weeks and perhaps earlier. Possibly depth perception in humans is structured in part by innate programming.

Human Perception and Evolution

Some of the visual perceptual abilities we have discussed have undergone considerable modification as a result of primate evolution. The arboreal habitats of the primates ancestral to humans would have placed a premium on accurate visual discrimination and visual-motor coordination. In fact, few mammals other than primates have to contend with climbing, descending, swinging from trees, and leaping from branch to branch to ensure their survival. These activities would have been aided immeasurably by binocular vision, depth perception, and precise coordination of visual and manual processes. It is probably no accident that such perceptual capacities are refined so highly in primates, including humans.

As some of our primate ancestors moved down from the trees and out into the expanse of the savannas, further improvements in perceptual accuracy would have been favored:

> Throughout the evolution of perception, the trend has been towards monitoring more accurately what is happening in the real world and assembling it to form an ever clearer world, artificial but representative, in the brain. Our ancestors, ranging as they did over territories far wider than those exploited by their ape cousins, were obliged to construct a mental map of those territories, delineated from many visible reference points, so as to transmit the whereabouts of rich sources of fruit, nuts, and other vegetable foods. This, in turn, would have placed an evolutionary premium on the capacity for detailed perceptual analysis of the environment (Leakey & Lewin, 1977, p. 188).

Supplement 1 Sleep and Dreaming

Why are the phenomena of sleep and dreaming covered in a chapter on perception? You may tend to equate sleep with unconsciousness and, therefore, with the *absence* of perceptual activity. Yet we sometimes recall dreams in which we have perceived people, familiar objects, places, and colors. We can be roused from sleep when someone calls us, indicating that we have perceived this event. We can also be aware of certain things happening in the environment, such as someone talking, even when our brain waves indicate that we are asleep. In addition, the brain is anything but inactive during sleep. Sleep and dreaming are just as much a part of our perceptual behavior as are the perception of form, color, and movement.

Sleep and dreaming are aspects of a more general phenomenon studied mainly by biologists — *biological rhythms.* Biological rhythms as discussed here are not to be confused with the "biorhythms" used to predict intellectual, emotional, and physical states according to date of birth. Such predictions are often found in newspaper columns and popular magazines, but this contemporary version of fortune-telling has little, if any, basis in scientific fact (Palmer, 1982).

There is now a great deal of evidence to suggest that the activities of living organisms tend to occur in rhythmic patterns. Such patterns have been related to a variety of external and internal factors, in a variety of species. These factors include such things as daily cycles of light and darkness, seasons of the year, lunar cycles, and changes in brain wave patterns.

The most widely studied biological rhythms are those that are repeated on a daily basis and that correspond to periods of light and dark — **circadian rhythms.** For example, humans tend to be most active during the day and to sleep at night. Many rhythms are triggered, and can be altered, by changes in external environmental stimuli. For instance, changes in the period of light an animal is exposed to can bring about changes in rhythmic behavior. (The procedure of changing a rhythm through manipulation of environmental cues is called *entrainment.*) However, most circadian rhythms that have been discovered have certain limits to their modifiability. For example, mice that are exposed in experiments to increasing or decreasing periods of light adjust their activity accordingly, but only as long as the light-dark cycle is at least twenty-one hours and no more than twenty-eight hours. When these boundaries are exceeded, activity tends toward a cycle of about twenty-three hours, apparently regulated by an internal clock. In other words, the effects of entrainment are lost, and a so-called free-running cycle controlled by endogenous (internal) factors takes over (Moore-Ede, Sulzman, & Fuller, 1982). Humans exposed to constant light over several days also show evidence of a free-running endogenous cycle of activity spanning about twenty-five hours (Aschoff, 1969). Light appears to synchronize circadian rhythms with the revolutions of the earth. Without normal light cues, endogenous rhythms function to "keep time."

Patterns of Sleep

Although itself part of a cycle, sleep contains a cycle of its own. There are different stages of sleep, each characterized by different kinds of brain wave activity. In order to understand these different brain wave patterns, recorded on an **electroencephalogram (EEG)** by means of electrodes attached to the scalp, it is first necessary to examine the patterns that occur during wakefulness. The normal waking state is accompanied by *alpha* and *beta* patterns. **Alpha wave** activity consists of a fairly regular pattern of brain waves that are relatively low in frequency and high in voltage. This pattern is typically observed when a person is awake and in a relaxed frame of mind with eyes closed. **Beta waves** are more irregular than alpha waves, and have a higher frequency and lower voltage. They occur when a person is in an alert, attentive state, as, for example, when engaged in mathematical reasoning or other challenging forms of mental activity.

As a person becomes more and more drowsy an EEG record will show progressively more alpha activity. Many people report experiencing the change from wakefulness to sleep as a gradual transition. However, physiological indicators and experimental evidence suggest that the change from nonsleep to sleep is rather abrupt (Carlson, 1981).

As sleep becomes deeper a new EEG pattern emerges—*delta* activity. **Delta waves** are lower in frequency and higher in voltage than alpha waves. Delta activity becomes increasingly recognizable as sleep becomes progressively deeper. At the deepest level of sleep, delta rhythms are quite regular, indicating apparent neural *synchrony,* or similarity in the pattern of firing in groups of neurons. Carlson (1981) provides the following analogy for explaining the phenomenon of synchrony:

> The activity of the individual neurons is similar to a large number of people chanting the same words (speaking synchronously). Beta activity is, for the same reason, referred to as *desynchrony;* it is more similar to a large number of people broken into many small groups, each carrying on an individual conversation. The analogy helps explain why desynchrony is generally taken to represent activation, whereas synchrony reflects a resting or depressed state. The group of people who are all chanting the same thing will process very little information; only one message is being produced. The desynchronized group, on the other hand, will process and transmit many different messages. The waking state of the brain is more like a desynchronized group of people, with much information processing going on. During delta sleep the neurons of the resting brain (especially the cortex) quietly murmur the same message in unison . . . (pp. 441–443).

REM Sleep Given our discussion so far, you might think that a typical night's sleep involves going through increasingly deeper levels of sleep until the deepest level is attained, and then reversing the journey in search of the waking state. This speculation would be correct, except for an interesting detour that occurs about an hour and a half after the person begins falling asleep. At this time delta activity, indicating the presence of a relatively deep level of sleep, is replaced with beta waves. If you were to see only the sleeper's EEG recordings at this point, you probably would conclude that he or she is awake, alert, and mentally active. However, another indicator, the **electromyogram (EMG)** would suggest otherwise. (EMG recordings are made from electrodes attached to skeletal muscle locations.) Specifically, the EMG would indicate a notable absence of muscle activity. You might get really confused if you looked at output from another recording instrument, the **electro-oculogram (EOG),** for it would be indicating rapid movements of the eyes, certainly not consistent with deep sleep. (EOG recordings are made from electrodes attached to the skin surrounding the eye.)

The only way to resolve your curiosity would be to examine the person directly, in which case you would notice several things. First, perhaps surprisingly, the person would be asleep. There would be a lack of muscle tonus, but you might observe occasional involuntary twitching of the feet, legs, or arms. The person's eyes would be closed, but if you looked closely you would likely see the eyes moving rapidly underneath the eyelids. If you were to wake the person, which might be difficult to do, he or she might well report having had a dream. All of these features constitute what is known as **REM (rapid eye movement) sleep** (Aserinsky & Kleitman, 1953; Berger, 1961; Dement & Wolpert, 1958).

Episodes of REM sleep occur about every ninety minutes during the sleep cycle, last about twenty to thirty minutes, and make up about 20 to 25 percent of sleep time in adults. In contrast, newborn babies spend about 50 percent of their sleep time in REM sleep (see Chapter 6). REM sleep has been observed in mammals and birds only (Maier & Maier, 1970), even though the vast majority of vertebrate species, and some invertebrates, sleep. Interference with REM sleep, by waking the sleeper up each time a REM period is observed, is associated with anxiety. Furthermore, repeated interruptions of the REM state lead to increasing periods of REM sleep later, an apparent attempt at compensation for lack of REM sleep (Dement, 1960).

Theories of Sleep

Neurophysiological Mechanisms What accounts for the timing of periods of sleep and wakefulness in animals that show circadian rhythms? The answer is far from clear, and indeed there may be more than one answer, depending on the species involved. It is known that the suprachiasmatic nucleus (SCN), a group of neurons in the hypothalamus, is involved in the timing of circadian rhythms in rats. These neurons have connections with the retinas of the eyes and have been shown to be responsive to light. Thus, it is thought that light triggers the SCN, and the SCN in turn times the sleep-waking cycle. Exactly what is involved in the timing function remains to be discovered. One possibility is that feedback from protein synthesis is an important factor. Nerve cells synthesize protein when they are firing, and it is possible that there are detectors sensitive to the amount of protein produced. When a certain level in production is finally attained, this would be detected and result in a slowdown in the firing rate. This could be accomplished by an increase in the thresholds of the neurons. With the passage of time the protein levels would drop, and again this would be detected. The result this time, however, would be an *increase* in the rate of firing of the neurons, perhaps due to *lowered* thresholds. This is a speculative hypothesis, but there is some supporting evidence for it (Carlson, 1981).

Neural centers involved in regulating states of sleep and wakefulness are thought to be in the brainstem, and in or near the thalamus and the hypothalamus. The reticular formation, which forms the core of the brainstem, and the pons (which includes a portion of the reticular system) appear to be critically involved in the regulation of sleep. (See Chapter 9 for a description of these neural structures.)

Certain neurotransmitters may also play a role in the sleep-waking cycle. For example, in cats, norepinephrine appears to be involved in initiating REM sleep, while serotonin may influence the progression to deeper levels of **NREM (non-REM) sleep** (Jouvet, 1967). Additional evidence implicating these two neurotransmitters comes from studies of the presence of these chemicals in the cerebrospinal fluid of rhesus monkeys. Garrick, Tamarkin, Taylor, Markey, and Murphy (1983) cite evidence for daily cycles of norepinephrine concentrations, with peak concentrations occurring during the day, and averaging 1.7 times higher than nightly troughs. In addition, these authors report finding a reverse rhythm for serotonin, with marked peaks occurring at night and troughs during the day. Garrick, et al. raise the possibility that the effective stimulus for altering concentrations of serotonin in the cerebrospinal fluid is light, mediated by the pineal body. The pineal body is located close to the thalamus and hypothalamus, and it is known to influence the timing of circadian rhythms in response to changes in light in certain species of birds (Brown, 1975). Preliminary findings, mainly with persons suffering from depression, implicate the pineal body as an influence in human circadian rhythms as well (see Chapter 9).

The Functions of Sleep Why do we sleep? Apparently it is not because our nerve cells "run down" from too much activity during the day. It is possible that sleep has a restorative effect on certain physiological functions, but there is mixed evidence concerning this hypothesis. Sleep deprivation produces no apparent long-term changes of a dramatic nature. In fact, the clearest effect of sleep deprivation is an increase in the need to sleep. Nevertheless, there are observations that suggest sleep may facilitate certain adaptive functions. We might suspect this simply because everyone sleeps and because people will compensate for deprivation of either REM or NREM sleep. The following experimental findings also suggest adaptive functions for sleep: (1) NREM sleep is associated with increased output of growth hormone (GH) in humans; (2) protein synthesis increases during sleep, especially REM sleep, in rats; (3) the formation of certain maze-learning memories in rats, and emotional memories in humans, is impaired (though not prevented) as a result of deprivation of REM sleep; (4) deprivation of NREM sleep is associated with complaints of lethargy, depression, muscle soreness, and joint pains in humans, though these effects are modest (Carlson, 1981). Taken together, this evidence suggests that sleep may have important physiological consequences, but it does not indicate that sleep is *necessary* for the production of GH, the synthesis of proteins, the formation of memory, or the repair of tissue. These functions go on at times other than periods of sleep.

Carlson (1981) comments on the possible adaptive value of sleep beyond the functions we have discussed:

> Sleep might not have any special restorative properties, but might simply function to keep an animal out of harm's way when there is nothing important to do. For example, our primitive ancestors were probably well served by the presence of a state that kept them from stumbling around in the dark, where predators were harder to see, and injuries were more likely to occur. For other animals, food could be obtained only during part of the day-night cycle. These animals would profit from a period of inactivity, during which less energy would be expended. Animals who have safe hiding places (e.g., rabbits) sleep a lot, unless they are very small and need to eat much of the time (e.g., shrews). Large predators (e.g., lions) can safely sleep wherever and whenever they choose, and indeed, sleep many hours of the day. In contrast, large animals who are preyed upon and have no place to hide, and who consequently must remain on guard (e.g., cattle), sleep very little. . . . Even if a biochemical need for sleep is eventually established, this will not rule out the fact that this state keeps many animals out of harm's way during part of the day (pp. 463, 464).

Dreaming

Dreaming is almost always reported by subjects awakened from REM sleep. Although dreaming is reported occasionally when NREM sleep is interrupted, the probability of this happening is very low, and the reported dreams seem to be qualitatively different from dreams experienced during REM sleep. REM dreaming tends to be narrative and concrete. NREM dreams are more likely to involve situations rather than narratives, sometimes nightmarish ones, such as a feeling of being suffocated (Carlson, 1981).

A number of themes common to dreams have been extracted from a review of the dream diaries of college students. For example, men dream about other men more often than they dream about women. However, women dream about men about as often as they dream about women. Dreams more often contain content involving misfortune than good news, and about 10 percent of dreams contain sexual themes. Approximately 30 percent of dreams are reported to be in color. However, it seems likely that most or all dreams occur in color, since interrupting subjects during REM sleep who otherwise claim they do not dream in color invariably yields reports of color dreaming. Some subjects claim they never dream, but nonetheless report dreaming when they are awakened from REM sleep in experiments. It seems likely that individual differences in color dreaming and dreaming activity are differences in *recall* of dream content, rather than substantive differences in dreaming behavior itself (Wallace & Fisher, 1983).

People have speculated for centuries about the meaning of specific dreams. Sigmund Freud believed that dreams can reveal threatening or unacceptable impulses and conflicts that cannot be recalled at the conscious level during periods of wakefulness (see Chapter 22). Carl Jung, one of Freud's followers who later broke with Freudian tradition, argued that dreams contain symbols of universal significance to humankind (Jung, 1964). These symbols, such as a cross or a wheel, reveal a shared (collective) unconscious with other human beings. The origin of these symbols, lies in our evolutionary past, according to Jung. In other words, our dreams contain "memories" inherited from our primitive ancestors. Jung's notions have a mystical quality about them are not consistent with our knowledge of mechanisms of evolution. The dream interpretation theories of Jung and Freud are not generally accepted by scientists outside the psychoanalytic tradition.

13

Memory

Memory and Cognition

Models of Memory

Short-Term Memory

Long-Term Memory

Construction and Distortion in Memory

Forgetting

The Development of Memory

Human Memory and Evolution

Supplement 1 The Serial Position Effect

Chapter Preview

Memory involves the storing, retaining, and retrieving of information. It is the basis for learning, and is intimately connected with all cognitive activities. For example, in order to perceive (understand) information from the environment, the nervous system must compare it with information already stored in memory. For information to be stored in memory in the first place, it must be perceived.

Memory has been characterized as a multistore system consisting of the sensory registers, discussed in Chapter 11, short-term memory, and long-term memory.

***Short-term memory* preserves information long enough for decisions to be made on the basis of that information. Short-term memory is the system we rely upon when we try to remember a phone number just long enough to dial it. The capacity of short-term memory is limited. However, one way to reduce the burden on short-term memory is to *chunk* items — group individual units of information into a smaller number of higher-order units, such as combining fifteen single letters into three five-letter words.**

Short-term memory is more than a temporary storehouse for information. It is considered a working memory that has many active functions, or control processes, such as organizing and rehearsing information. Organization and rehearsal influence maintenance of information in short-term memory, and transfer of information to long-term memory.

Long-term memory can be characterized as containing episodic and semantic information. Episodic information consists of a record of events, while semantic information consists of meanings for things. Although psychologists traditionally have emphasized the verbal nature of information stored in long-term memory, it seems clear that concrete physical characteristics such as visual images and sounds are also stored. Items appear to be stored in an *associative* fashion in long-term memory.

Theoretical explanations of forgetting are similar for short-term and long-term memory — interference and decay over time.

Age-related changes in memory can be due to changes in the structural components or the functions of memory. Much of the evidence favors changes in functions as the reason for apparent developmental differences in memory, especially long-term memory. But structural changes cannot be ruled out and, indeed, may account for some of the age variation in short-term memory span.

The chapter concludes with a speculative discussion of semantic memory from an evolutionary perspective. Contemporary theories of semantic memory may be enhanced and made more precise by considering the evolutionary aspects of human memory.

The supplement to this chapter discusses the serial position effect.

The study of **memory** — the processes involved in *storing, retaining,* and *retrieving information* — has been a central concern of psychology, off and on, for the past hundred years. Currently this concern is in the "on" phase; for over two decades the scientific study of human memory has been a major preoccupation of experimental psychology.

Memory and Cognition

Learning Recalling our definition of *learning* as the acquisition and retention of information resulting from experience, you may wonder where learning leaves off and memory begins. Learning means that a *change* has occurred within an individual. This is often inferred from an observed change in behavior that is correlated with a particular experience. Psychologists who investigate *learning* usually focus on this change and on conditions in the external environment which bring it about. Psychologists who investigate *memory,* on the other hand, usually focus on the *internal cognitive processes* — storage, retention, retrieval — that operate to produce learning.

If an organism could not remember in some way, it could not learn, and this could have grave implications for survival. Learning and, therefore, memory are widespread in the animal kingdom. Many species show evidence of habituation, a simple kind of learning in which a response gets weaker as a result of repeated presentations of a stimulus. In order to habituate, an organism must be able to store and retain information pertinent to the stimulus. Habituation indicates that an organism remembers its previous encounters with a stimulus.

Other kinds of learning also depend on memory. In both classical conditioning and instrumental learning there is an improvement in performance with practice. But try to imagine improvement without memory. Observational learning also shows a dependence of learning on memory. A child who imitates an act two weeks after seeing it performed has clearly stored, retained, and retrieved information.

Just as learning depends on memory, the reverse is also true. The effectiveness and efficiency of memory depend upon what has been learned in the past. Suppose you are given the following list of terms to remember, for recall at a later time: *yardarm, boom, jib, sheet, mast, spinnaker, head, main, genoa, starboard, helm, tiller, keel, gaff.* If you have done some sailing you would probably have little difficulty with the list because of previous familiarity with these sailing terms—you have already learned them. If you are a "landlubber," on the other hand, you might have to approach most of these terms as if they were nonsense syllables, and thus devote considerable effort to storing, retaining, and retrieving them.

Past learning can do more than give additional meaning to what we try to remember; it can also affect the way we actually go about trying to store, retain, and retrieve information. In other words, we can and do *learn* things that enable us to remember more effectively and efficiently. Through such processes as trial and error, imitation, and sometimes direct instruction, we gain useful knowledge about our own strengths and weaknesses as rememberers, and about the strategies that are most effective in dealing with particular memory demands. For example, strategies that are most effective for storing material in preparation for a multiple-choice exam may not be best for preparing for an essay exam. Knowledge we have acquired about our own memory abilities, strategies, and other cognitive functions is part of our **metacognition,** which means cognition about cognition—knowing about knowing.

Perception The act of *perceiving* can be characterized as *making sense* out of, or interpreting, *physical sensations.* To interpret sensory input is to derive meaning from it, a process that cannot take place without access to some sort of mental dictionary. In order to perceive the visual information that is forming rapidly changing images on the retinas of your eyes, your brain must integrate and compare these images with information already stored in memory. This information consists of stored visual symbols—letters, words, word sequences—and the images, sounds, meanings, and probable meanings they conjure up. Even the simplest perceptual acts, ones we take completely for granted, require the involvement of memory. A simplified version of the interplay between perception and memory is depicted in Figure 13.1.

Perception also influences memory, as is indicated by the arrows connecting memory with processing and perception in Figure 13.1. For information to be

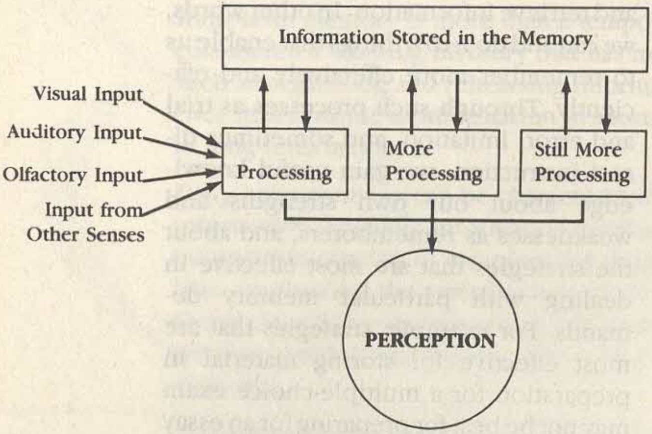


FIGURE 13.1 The interplay of perception and memory.

stored in memory in the first place, it must be perceived. And the objectivity of our memories can be influenced greatly by our initial perception of an event. The angle from which we view an accident, for example, may create a memory quite different from those of other eyewitnesses.

Suppose you hear a gunshot and see a man falling from a fire escape seven stories up on a building. You also see another man standing at the top of the escape with a smoking revolver in his hand. Obviously, your recall of these events some time later would be quite valuable to an attorney bent on prosecuting the man with the gun. However, even if your recall were accurate, the initial *perception* of the events may have been incomplete because of your viewing angle. For example, suppose the man left holding the gun was actually innocent; he had simply tried to take the gun away from the other man, who accidentally shot himself in the struggle. If that were the case, your testimony, based on accurate recall of incomplete information, might convict an innocent person.

Memory's Central Role In the past memory was conceptualized as a static storage bin, and memories as the contents of that bin. The functioning of memory was considered to be a relatively automatic and low-level kind of activity. But that way of characterizing memory is completely outmoded today. Memory is at the heart of information-processing systems. It plays a vital role in all kinds of cognitive activities, from the most elementary perceptual act to the most sophisticated form of abstract reasoning. Without memory we could not *perceive* various stimuli; we would not know whether to increase or decrease our *attention* to a stimulus; our *daydreaming, fantasizing,* and *imagination* would be severely curtailed; *creative thought* would be stifled; engaging in *language* would be impossible; and of course we would be totally unable to profit from our experiences—to *learn.* In short, it is difficult to imagine that an organism could behave cognitively and not also store, retain, and retrieve information.

Models of Memory

Over the past twenty years psychologists have devised various models of memory based upon information-processing concepts. The models that have received the most attention are referred to as **multistore models** of memory. A multistore model divides memory into separate structures, or stores, which differ from one another in terms of their capacity and duration. A more recent alternative approach is to view memory as a unitary process that is the result of perceptual processing. In this view, capacity and duration of memory depend upon the "depth" of processing the information

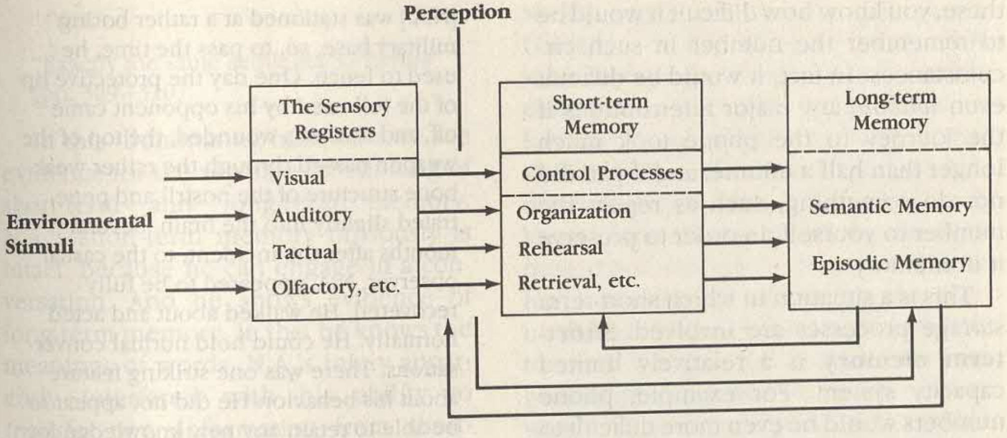


FIGURE 13.2 A multistore model of memory.

receives when it is perceived. The deeper the level of processing, the more likely it is that information will be remembered and the more permanent the memories. This alternative to multistore models has been called the **levels-of-processing** approach to memory (Craik & Lockhart, 1972).

Recently the basic assumptions of the levels approach have been questioned. Some researchers now believe that this approach is less fruitful than the multistore model for understanding human memory (Baddeley, 1978; Nelson, 1977; Wickelgren, 1981). Our discussion of memory in the remainder of the chapter is therefore organized around a multistore model. This model consists of three memory stores: the sensory registers, short-term memory, and long-term memory (Figure 13.2).

The sensory registers, discussed in detail in Chapter 11, appear to be relatively large-capacity systems for preserving information very briefly. Unless the sensations held in the sensory registers are analyzed quickly and "read into" a more permanent storage system, they will fade very rapidly. Most of us are not even conscious of this form of memory. The more permanent stores the sensory registers feed into, short-term and long-term memory, are the systems we are usually referring to when we speak casually about memory. However, they are two rather different kinds of memory stores, as we will show.

Short-Term Memory

Suppose you are watching television in the den. A commercial comes on advertising a book entitled *How to Improve Your Memory in Five Easy Steps.* You attend to the toll-free phone number you can dial in order to receive a copy of the book at a "reduced price." The phone is one flight of stairs away, and there is no pencil and paper at hand. Thus your task is the seemingly simple one of committing the phone number to memory long enough to get to the phone and dial the number.

How easy do you suppose it would be to recall the number accurately if someone began talking to you as soon as you started for the phone, or if someone called on the phone just as you got there? If you have ever had experiences such as these, you know how difficult it would be to remember the number in such circumstances. In fact, it would be difficult even *without* any major interruptions if the journey to the phone took much longer than half a minute, and if you did not do something, such as repeat the number to yourself, in order to preserve it in memory.

This is a situation in which short-term storage processes are involved. **Short-term memory** is a relatively limited capacity system. For example, phone numbers would be even more difficult to remember if they were nine or ten digits in length. For adults, immediate memory span for a series of unrelated stimuli ranges between five and nine items on the average. However, there are ways of overcoming this limitation, as we shall see later in the chapter.

The duration of short-term memory varies, depending on the species and many other variables. It is estimated to be about thirty seconds for human adults.

Information in short-term memory is not nearly as vivid or complete in physical detail as it is in the sensory registers, although it does appear to involve physical characteristics such as sounds, words, and visual images. However, the information in short-term memory is more meaningful than information in the sensory registers.

There are many sources of evidence for the existence of short-term memory, and for its functional separation from long-term memory, beyond the commonsense observation that it is difficult to remember phone numbers for any length of time. Perhaps the most dramatic support comes from clinical observations of individuals who have incurred damage to certain areas of the brain. Consider the case of N.A. (Lindsay & Norman, 1972):

> [N.A.] was stationed at a rather boring military base, so, to pass the time, he used to fence. One day the protective tip of the foil used by his opponent came off, and N.A. was wounded; the top of the weapon passed through the rather weak bone structure of the nostril and penetrated slightly into the brain. Several months after the incident, to the casual observer, N.A. appeared to be fully recovered. He walked about and acted normally. He could hold normal conversations. There was one striking feature about his behavior: He did not appear to be able to retain any new knowledge for more than a very short time. . . . One of the psychologists studying N.A.'s memory difficulties was Dr. Wayne Wickelgren. . . . As professor Wickelgren tells the story:
>
> "I was introduced to N.A. in a small coffee room in the Psychology Department at M.I.T. The introduction went approximately as follows. . . .
>
> " 'Wickelgren, that's a German name, isn't it?'
>
> "I said, 'No.'
>
> " 'Irish?'
>
> " 'No.'
>
> " 'Scandinavian?'
>
> " 'Yes, it's Scandinavian.'
>
> "After having about a five-minute conversation with him, I left to go to my office for perhaps another five minutes. When I returned, he looked at me as if he had never seen me before in his life, and I was introduced to him again. Whereupon he said:
>
> " 'Wickelgren, that's a German name, isn't it?'
>
> " 'No.'
>
> " 'Irish?'
>
> " 'No.'
>
> " 'Scandinavian?'

"'Yes.'

"Exactly the same sequence as before" (pp. 309–310).

In this illuminating interview we see evidence for the separate functioning of short-term and long-term memory. N.A.'s short-term memory obviously is intact, because he can engage in a conversation. And he shows evidence of long-term memory, in that he knows the meanings of words. N.A.'s injury apparently interfered with his ability to *transfer* new information from short-term to long-term memory. Several documented clinical cases such as this one point to a neural basis for regarding short-term and long-term memory as separate functions.

The Content of Short-Term Memory

In what form is information coded or represented in short-term memory? Studies of short-term memory in human adults suggest that much of the representation is *verbal,* especially acoustic or articulatory, in nature (Horton & Mills, 1984). For example, we often code items in terms of the *sounds* of their names; we even do this on occasion when trying to store *visually* presented items, such as letters, digits, or words.

Obviously not all short-term memory storage is verbally based; if it were, deaf people, infants, and nonhuman animals would have no short-term memory. That seems preposterous, and the evidence suggests that it is. For example, individuals with normal hearing seem to store the *sounds* of letters and words in short-term memory, even if the letters and words are presented visually (Conrad, 1962, 1964). On the other hand, deaf people tend to store the *shapes* of visually presented letters and words (Conrad, 1972), although some deaf subjects also show evidence of acoustic coding (Hanson, 1982). Even human infants as young as three months of age show evidence of short-term recognition of visual stimuli (Kail, 1979). As far as we know, none of the infants tested were precocious enough at three months to have been capable of labeling the stimuli. With respect to nonhumans, attempts to teach language to chimpanzees and gorillas provide many instances of what would seem to be visual (and manual) short-term memory. It seems quite reasonable to speculate that other species have visual short-term memory as well. Finally, there is evidence that normal human adults can store information visually in short-term memory (Kosslyn, Ball, & Reiser, 1978; Shepard, 1978).

Retrieval from Short-Term Memory

Given the limited capacity of short-term memory, it might seem that active or systematic retrieval should not be necessary. The amount of information short-term memory can hold is hardly enough to require a thorough search through the rather shallow caverns of this memory store; the items are either there or not—or so it might seem.

In a series of important studies, Sternberg (1966, 1967, 1969) found evidence of the use of systematic retrieval strategies by adults for locating items in short-term memory. His approach to short-term memory retrieval was novel because he used *reaction time,* rather than amount recalled or recognized correctly, as an indication of what subjects were doing to retrieve items. Sternberg presented sequences of items (digits or letters) for subjects to remember. A given sequence, such as 7 5 9 2, was called a *memory set.* After receiving a memory set, the subject was presented with a *test item.* All the subject had to do was decide whether or not the test item belonged to the memory set; it was not necessary to report or recall the memory set items. This is basically a *recognition* test of memory, and a rather easy one for most subjects.

Sternberg was interested in how long it took subjects to recognize whether a test item was a member of the memory set. Why the concern over reaction time? Sternberg was trying to test alternative hypotheses about retrieval from short-term memory.

One hypothesis states that retrieval is a *parallel* process, that is, that all of the items in short-term memory are examined *simultaneously* when a particular piece of information is being located. The alternative hypothesis states that retrieval is a *serial* process in which items are examined *one at a time.* Sternberg reasoned as follows: If people engage in parallel search for information, then it should take about the same amount of time to reach a decision regarding the test item whether the memory set is large or small. However, if people compare each item in the set with the test item in a serial fashion, then it should take longer to respond when there are more items in the memory set.

The findings are consistent with the idea that people engage in *serial* search when retrieving material from short-term memory. Many researchers have replicated Sternberg's results, finding that the characteristic linear reaction-time function holds whether the memory set items are presented all together or one at a time, and whether they are presented visually or aurally.

Short-Term Memory Control Processes

Short-term memory is something more than a temporary and not very large storehouse for information. Short-term memory is characterized by many control processes that perform a number of operations vital not only to memory in particular, but to thinking and communication in general. In this section we emphasize the working characteristics of short-term memory by examining the control processes of organization and rehearsal.

Organization Organization encompasses a number of functions designed to increase the amount of information in short-term memory. A term often used for organization is **chunking.** *Chunking* involves combining several different items to form a *higher-order unit*—a *chunk*—of information. Grouping items on the basis of their temporal or spatial proximity to one another is one form of chunking.

Chunking can also involve combining items on the basis of a *perceived set of meaningful relations* among those items other than temporal or spatial ones. For example, individual letters can be chunked to form a single word, words to form phrases, phrases to form sentences, sentences to form a story, and so on. Also, words in a list might be chunked together because they are all highly associated to one another (for example, *sharp* and *pain*), or because they belong to the same conceptual category (*automobile* and *train*). In some cases, the perceived set of meaningful relations may be a *rule* for remembering items. (See if you can devise a single rule for remembering this twelve-digit sequence: 3 9 2 7 8 1 2 4 3 7 2 9.)

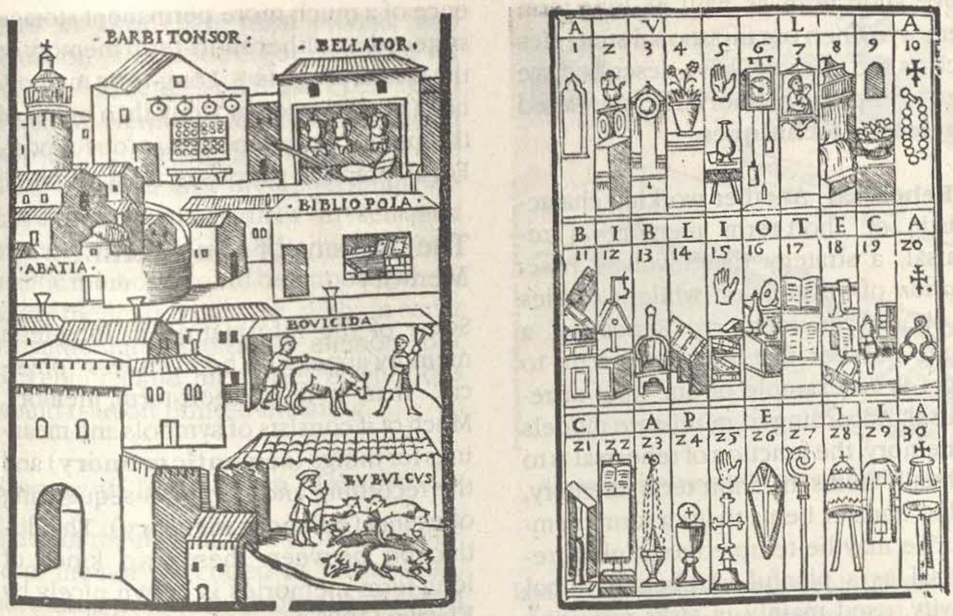


FIGURE 13.3 The method of loci dates back to Greek and Roman times. This sixteenth-century woodcut shows at left buildings that can be used as locations (loci) for remembering the items pictured in rows on the right. Each row belongs in a particular location: top row = courtyard; middle row = library; bottom row = chapel. Every fifth item shows a hand, and every tenth a cross, providing a means of coding the items by the fingers of each hand.

In other cases, the perceived set of meaningful relations may be created or *elaborated* by the learner. For example, a cocktail waitress might conjure up a vivid visual image of the man who orders "Chivas on the rocks" leaving a luxurious mansion in a chauffeur-driven Rolls Royce. The man sitting next to him at the bar orders "scotch-rocks." In order to make certain that the second man gets the (cheap) house scotch, the waitress imagines him as the chauffeur. Visual imagery can be an extremely effective aid to memory. One particularly effective imagery strategy is known as the **method of loci,** which was used by the early Greeks to remember speeches in the absence of writing materials.

> To use the method of loci, you must first establish a list of images of places which are familiar to you, such as the distinctive [rooms in] . . . your own house. . . To learn any new set of items, you simply take a "mental walk" through your list of loci [rooms], placing successive items in your imagination [in] successive [rooms] along the route. You should connect the items to their [rooms] by visualizing some interaction between the item and something [meaningful] in each [room]. Then, when you need to recall the items, you simply take another mental walk along the route and "observe" the items that have been deposited there (Bourne, Dominowski, & Loftus, 1979, p. 361–362).

We do not always think to use organizational strategies—some are elicited automatically. But their deliberate employment in the proper context can improve short-term as well as long-term memory. When organizational strategies such as the ones we have described are used to improve memory, they are called **mnemonic techniques.**

Rehearsal Another working characteristic of short-term memory is rehearsal, a strategy that involves *reactivation* of information while it resides in short-term memory. Repeating a phone number that you don't want to forget is an example of one kind of rehearsal. According to multistore models of memory, the function of rehearsal is to maintain items in short-term memory, and to transfer items to long-term memory. We may be tempted to think of rehearsal as a planful, deliberate verbal activity, used mainly in tasks requiring rote memory. Although this may be true of some kinds of rehearsal, it does not apply to others. It is difficult to imagine, for instance, that pigeons are very planful or deliberate in situations that require them to remember something, and certainly they are not verbal. Nevertheless, there is reason to suspect that pigeons (and other animals) do reactivate items in memory (Blough, 1959). Undoubtedly, this kind of rehearsal is a relatively automatic process that may be a natural property of nervous system functioning. Thus it would seem that *rehearsal* is best thought of as a very general term that may or may not involve notions of deliberation.

Long-Term Memory

The final memory structure in our multistore model is **long-term memory.** The fact that we can remember things that happened to us days, months, or years ago is clear indication of the existence of a much more permanent storage system than either short-term memory or the sensory registers. Long-term memory has a much larger capacity than either of the other two memories in our model. For all practical purposes, it is unlimited.

The Content of Long-Term Memory

Some of the information in long-term memory appears to be even less "physical" than it is in short-term memory. Much of it consists of symbols and meanings for things (**semantic memory**) and the recording and temporal sequencing of events (**episodic memory**). The distinction between these two kinds of long-term memories is drawn nicely by Klatzky (1980):

> It is semantic memory that holds all the information we need in order to use language. It includes not only words and the symbols for them, their meaning and their referents (what they represent), but also the rules for manipulating them. Semantic memory holds such things as the rules of English grammar, chemical formulas, rules for adding and multiplying, knowledge that autumn follows summer—facts that do not depend on a particular time or place, but are just facts. Episodic memory, in contrast, holds temporally coded information and events, information about how things appeared and when they occurred. It is our memory for personal history, such as "I broke my leg in the winter of 1970." It stores things that depend on context—"It is not every night that I have fish for dinner, but I had it last night" (pp. 178–179).

Although there is good reason to make the semantic-episodic distinction, it must be emphasized that these two memories work together and are interdependent. Semantic information derives in large part from storage and retention of episodes. For example, we had to experience and retain episodes in which we were told that red lights mean stop and green ones mean go before these symbols and their meanings became permanent fixtures in semantic memory. Without episodic memory, semantic memory would be impoverished, to say the least. Likewise, without some semantic information in memory our perceptions and memories of episodes would take on limited meaning.

Storage in Long-Term Memory

Much of the information in human long-term memory is coded in verbal form, according to sounds (words) and verbal meanings that characterize stimuli. However, visual-spatial imagery is also a very effective means of representing information in long-term memory (Bower & Winzenz, 1970; Paivio, 1971).

Information in long-term memory is stored in an organized, *associative* fashion. This means that items that are related in some meaningful way are stored in memory *together.* Certain stimuli often occur together in time and space, such as the words *animal, vegetable,* and *mineral* (time), or *silverware* and *table* (time and space). Other stimuli, although they may not occur together, are related because they belong to the same category of objects. Dogs and sharks rarely make an appearance together, yet they are related conceptually because they are both animals. Stimuli that are related temporally, spatially, or conceptually appear to be linked together in associative units.

MEMORY CONFERENCE
PSYCHOLOGISTS CONFERENCE AT CARDIFF TO DISCUSS MEMORY

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"I apologise for the non-arrival of the guest speaker — — who I'm almost sure I invited!"

Evidence for this kind of organization in memory comes from a variety of sources. For example, if adults are given a long list of words to be recalled at some later time, and if items on this list can be grouped together in meaningful ways, this will be reflected in the subjects' recall patterns. Suppose the following words are presented one at a time, in this order: cat, truck, rose, dog, fork, car, daisy, bird, train, spoon, tulip, knife. If you were asked to recall this list in any order you wished, you might well tend to recall items together that "belong" together—all of the vehicles together, the flowers together, and so on. This is called *category clustering,* and it often occurs spontaneously in adults. It reflects the fact that information is being stored and retrieved in an *organized* fashion.

There are many different models explaining how information is stored in long-term memory, but most of them stipulate that items are stored in some sort of *associative network.* It is as if different pieces of information are located at different positions, and connected to one another in various ways. Some items are "closer" to one another in the network than others. For example, *dog* and *cat* would be more closely associated in

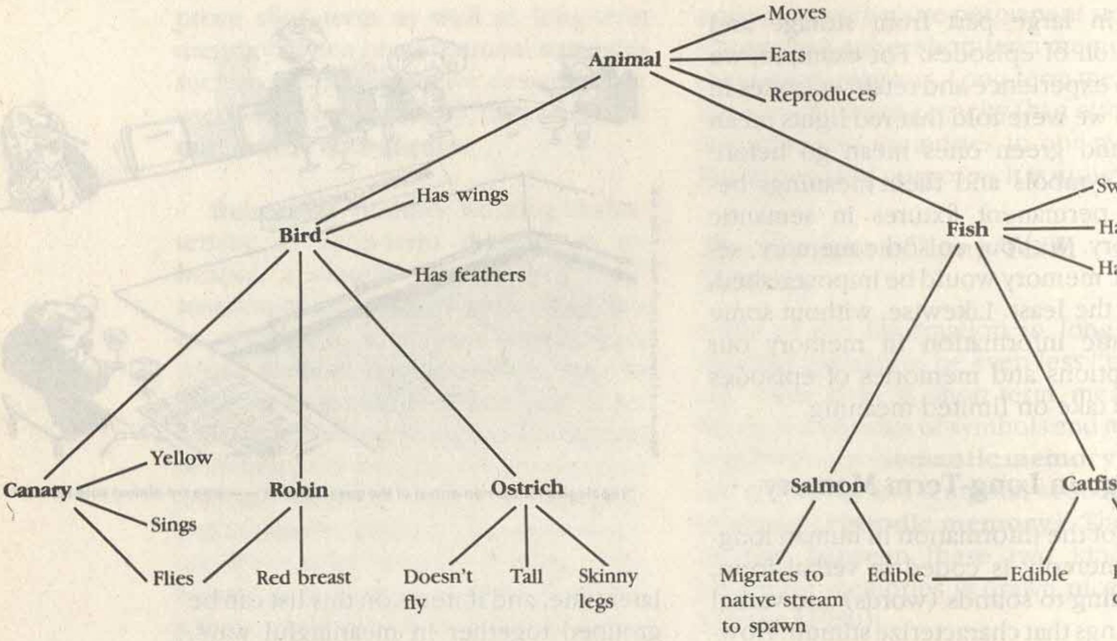


FIGURE 13.4 A model of information storage in long-term memory showing the associative nature of memory.

a memory network than *dog* and *bumblebee.*

The information that constitutes a network in long-term memory probably consists of single units, like *dog* or *bumblebee,* meaningful *propositions* related to these units ("dogs bark," "bees sting"), *visual images,* and other *sensory representations,* such as sounds and smells (Figure 13.4).

Retrieval from Long-Term Memory

There are two major ways we can retrieve information — **recognition** and **recall.** Before we go on to describe the strategies involved in retrieval, a few comments about recognition and recall tests of memory are in order, since these tests provide the data for theories of retrieval.

Recognition tests involve presentation of items to be remembered, called target items. Then a choice item is presented that may or may not be one of the original target items. The subject must identify whether or not the choice item was one of the items to be remembered. There are different forms of recognition tests. For example, we might present 150 photographs depicting animals, people, or objects, and then test for recognition some time later. Another form of recognition test might involve the presentation of two or more items on each test trial. In this case, only one of the items would be from the original list of items to be remembered. As you may recognize, this is the standard format of multiple-choice examinations. In general, recognition accuracy is very high, even when there are intervals of days or months between presentation of the target items and the recognition test.

Recall tests involve presentation of target items followed by information that cues the subject to reproduce the items.

In this case, the subject does not have the luxury of encountering one of the target items again; it must be dredged up from memory. Essay exams are recall tests of memory. In general, *recalling* items accurately is more difficult than *recognizing* them, although recognition can become very difficult if the choice items are very similar or highly related to the items to be remembered.

Although it may seem that the retrieval processes used in recall differ greatly from those used in recognition, there are some basic similarities between the two. In both cases it appears that *active search* is undertaken to locate the relevant information in memory. And in both cases *decisions* must be made in the process of identifying the information that is to be retrieved.

There are many illuminating examples that show how people go about retrieving information in recall tasks. We have all had the experience of trying very hard to remember someone's name, the name of a song, or a term that is used to convey a particular meaning. We know that we know the information we are searching for; it is on the "tip of the tongue." Results of a study investigating the "tip of the tongue" (TOT) phenomenon tell us something about retrieval strategies as well as the way information is organized in long-term memory.

Roger Brown and David McNeil (1966) observed subjects trying to recall terms that were associated with a particular meaning. For example, they would read a dictionary definition to a subject, and then ask for the name of the object that had been defined. One of their definitions was "A navigational instrument used in measuring angular distances, especially the altitude of the sun, moon, and stars at sea." Many subjects experienced a TOT phenomenon when they tried to recall the name of this instrument. Most interesting was the way subjects went about trying to retrieve the knowledge they knew they possessed. Even though subjects in the Brown and McNeil experiment could not identify the word *sextant* immediately, they seemed to know how many syllables it had and what it sounded like ("something like *secant* or *sexton*"). They seemed to be tuned in to conceptually related words such as *compass* and *protractor,* but also knew that these were *not* the words they were looking for. Figure 13.5 shows a TOT pattern of responding for a subject in a different study. This subject had suffered damage to the left hemisphere of the brain, resulting in a serious language disorder which made naming pictures of common objects very difficult.

These observations and many others suggest that items are stored in memory in meaningful networks, and that we trace the routes connecting one piece of information to another in the process of retrieval.

What are the factors that influence how much information can be retrieved? The major factors seem to involve ***how the information was coded*** in memory in the first place, and the ***kinds of retrieval cues used*** or ***supplied.***

Information that is coded in a highly organized form makes for easier retrieval. This is because knowledge of the organizational categories themselves can be used in the act of retrieving. Consider category clustering—organizing items to be remembered according to higher-order category headings. Generally speaking, increases in category clustering are accompanied by increases in recall accuracy. One reason for this has to do with retrieval. All we have to do is recall the category headings we used

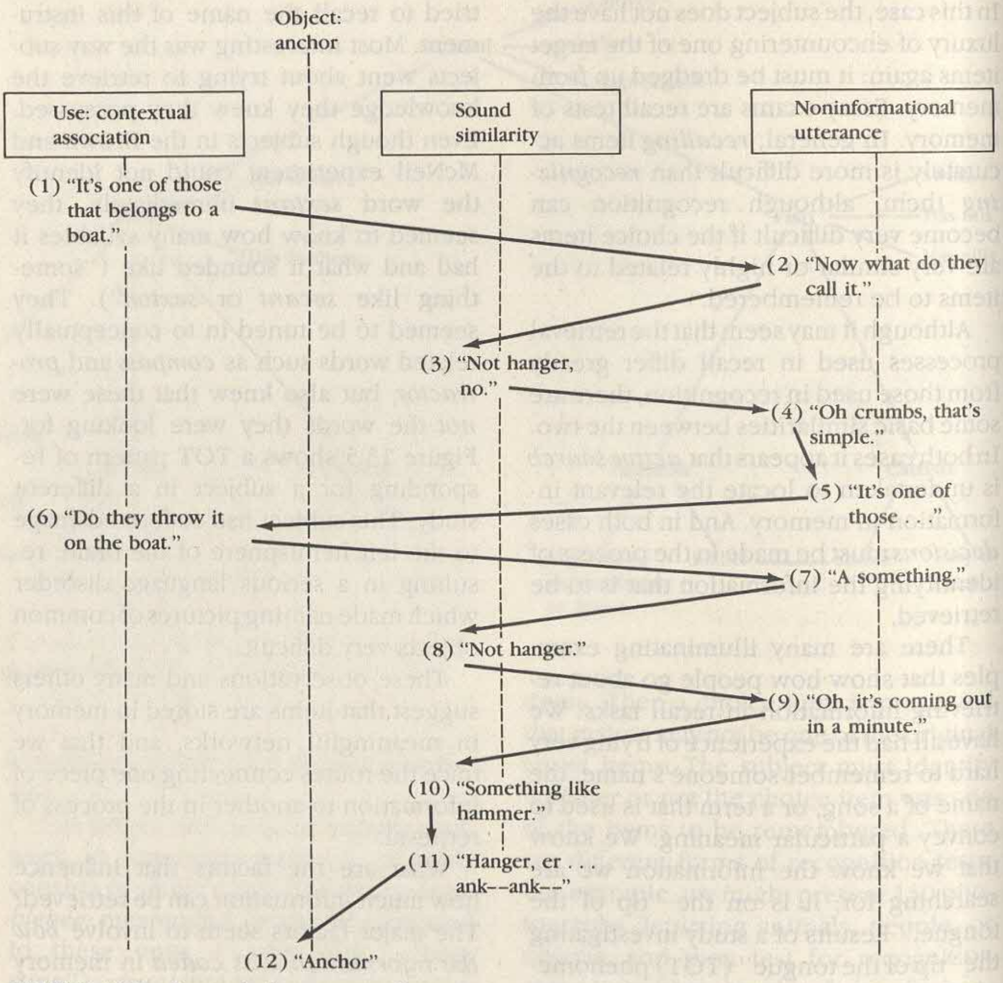

Object: anchor
Use: contextual association
Sound similarity
Noninformational utterance
(1) "It's one of those that belongs to a boat."
(2) "Now what do they call it."
(3) "Not hanger, no."
(4) "Oh crumbs, that's simple."
(5) "It's one of those . . ."
(6) "Do they throw it on the boat."
(7) "A something."
(8) "Not hanger."
(9) "Oh, it's coming out in a minute."
(10) "Something like hammer."
(11) "Hanger, er . . . ank--ank--"
(12) "Anchor"

FIGURE 13.5 Record of an attempt by an aphasic patient to remember the word associated with a picture of an anchor.

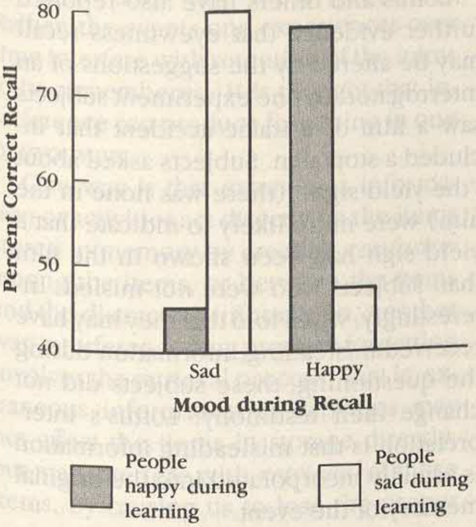
originally to code the items in memory. Once we do this, we have available some very informative retrieval cues to direct our memory search. Recalling each category heading activates associated semantic and episodic information already in long-term memory.

There are many other examples that illustrate the important relationships between memory coding and retrieval. Even physical and emotional states at the time information is coded in memory can be important considerations in the retrieval process. For example, many studies have indicated that information is retrieved better when the physical state of the individaul at the time of retrieval matches that when the information was first acquired. Much of the research has focused on states induced by drugs or hypnosis.

Suppose a man learns a list of words while "high" on an amphetamine substance. Generally speaking, his ability to recall the list at a later time will be better if he is again "high" on the same drug. This effect has been called **state-dependent memory,** and it has been demonstrated in humans and nonhumans alike with a variety of drugs other than amphetamines, including alcohol, marijuana, and various barbiturates.

It is also possible to show state-dependent memory effects for physical and emotional states induced by hypnosis. Gordon Bower (1981) has shown that hypnotically inducing subjects to be "happy" impairs their memory for lists of words learned while they were "sad," and vice versa (Figure 13.6). It appears that information acquired while one is happy (or sad) might be organized and rehearsed within a happy (or sad) context. In other words, propositions about emotional states (such as "Gosh, I'm in a good mood today," or "Hey, this memory task is fun") may be stored along with the information to be remembered. Being happy at the time of recall then functions as a cue for retrieving those propositions as well as associated information.

FIGURE 13.6 People's memory for items learned when they were hypnotically induced to be happy is best when they are also happy during recall. If they were sad during learning, performance is best if they are also sad during recall.



One implication of Bower's work is that happy people tend to continue to be happy, and sad people sad, because they are more likely to retrieve memories that were stored when they were in those moods.

> A person in a depressed mood will tend to recall only unpleasant events and to project a bleak interpretation onto the common events of life. Depressing memories and interpretations feed back to intensify and prolong the intense mood, encouraging the vicious circle of depression. One class of therapies for depression aims at breaking the circle by restructuring the way depressed people evaluate personal events. Thus patients are taught to attend to and rehearse the positive, competent aspects of their lives and to change their negative evaluations (Bower, 1981, p. 69).

State-dependent memory illustrates a more general principle concerning retrieval, the principle of *encoding specificity* (Tulving & Thomson, 1973). This principle states that (1) items are coded in memory the way they are perceived initially; (2) the particular way items are coded determines the kinds of retrieval cues that can access the items; and (3) memory performance will be best when there is a close correspondence between the conditions surrounding coding and those surrounding retrieval.

The basic idea is that a multitude of events happening outside and inside the individual are coded along with the information to be remembered. These events, called *contextual cues,* are entered into the memory network involving the items to be remembered. The closer the retrieval context approximates the coding context, the better the recall for information embedded within that context in memory.

Construction and Distortion in Memory

Anyone who has done some "people-watching," including self-observation, will not be surprised to learn that a person's recall of events often contains embellishment or other forms of distortion. In other words, people often do not remember the exact wording of stories they have heard or the precise sequence of events they have witnessed. It has been well documented that we tend to remember the *meanings* of stories and events, at the expense of the exact wordings or sequences. Sometimes we selectively forget or distort items that do not fit in well with our preconceived notions. At other times we may infer and "remember" things that we did not actually perceive because they are consistent with our expectations and biases.

Eyewitnesses to an accident or crime do not always remember accurately what they have seen, even though they may be quite confident of their testimony.

Some of the recent research on memory construction and distortion has profound implications for the functioning of our legal system. Elizabeth Loftus and her associates have provided systematic evidence that bears on the credibility of eyewitness testimony (Loftus, 1979). Loftus has found that when subjects in an experiment are asked "leading questions about an event they have witnessed, they often report things they did not see. For example, two groups of subjects see a film depicting a car accident. Subjects in one group are asked whether they saw "*the* broken headlight." Subjects in the other group are asked whether they saw "*a* broken headlight." Subjects in the first group report they have seen a broken headlight more often than subjects in the second group. What is both intriguing and disturbing about this finding is that it holds whether or not there was a broken headlight in the film.

Loftus and others have also reported further evidence that eyewitness recall may be altered by the suggestions of an interrogator. In one experiment subjects saw a film of a traffic accident that included a stop sign. Subjects asked about "the yield sign" (there was none in the film) were more likely to indicate that a yield sign had been shown in the film than subjects who were not misled. Interestingly, when told that they may have received misleading information during the questioning, these subjects did not change their testimony. Loftus's interpretation is that misleading information is actually incorporated into the original memory of the event.

Forgetting

There are two major alternative theories of forgetting from short-term memory—trace decay and interference.

Trace Decay Theory

According to **trace decay theory,** forgetting occurs as a result of the passage of time. This explanation, elaborated upon by Donald Hebb (1949), states that a neural trace of a stimulus—the representation of the stimulus in the nervous system—is established at the time the stimulus is perceived and continues to exist for a brief period. However, the trace gradually loses strength unless it is reactivated, as would happen when we rehearse an item we are trying to remember. The main feature of this theory is that decay of the trace is a *passive* process, brought about only by the passage of time.

Interference Theory

Interference theory is a way of explaining forgetting in more active terms. According to this theory, passage of time in itself does not cause forgetting. Rather, the events one experiences over time interfere with retention of the items to be remembered. It is thought that interference can produce forgetting in one of two ways.

One way is that extraneous information or activities act directly on the items stored in memory by creating *confusion* among the items, or between the items and the distracting information. Another way interference may produce forgetting involves the retrieval process. That is, extraneous information or activities may not affect the items in storage directly, but may interfere with *retrieval* of those items, by causing us to lose the proper "addresses" or locations of the items in storage. However, the net effect would be the same—forgetting.

Which Theory?

It seems clear from numerous investigations that *interference* is probably a major source of forgetting in both short-term and long-term memory.

Jenkins and Dallenbach (1924) showed that college students who *slept* after learning a list of nonsense syllables forgot less than did students who remained awake during the interval between the original learning and the test for retention (the retention interval). Minimi and Dallenbach (1946) reported that cockroaches physically immobilized after learning a conditioned avoidance response forgot less compared to those allowed to engage in normal activity (Figure 13.7). The rationale of both experiments was that sleep or inactivity would provide less interference with items in memory than normal waking activity.

The fact that more forgetting occurred when subjects were awake, or active, during the retention interval seems quite consistent with interference theory, but not with decay theory. If forgetting were due only to decay over time, independent of interference, we should see similar forgetting curves whether subjects were awake or asleep, active or inactive, during the retention interval.

Although these findings were replicated by others, and seemed quite damaging to decay theory, they are not as clear as they might seem. It turns out that the difference in forgetting between "sleep" and "active" groups is not nearly so great when *meaningful* materials, as opposed to nonsense syllables, are used as stimuli. Also, it appears that *time of*

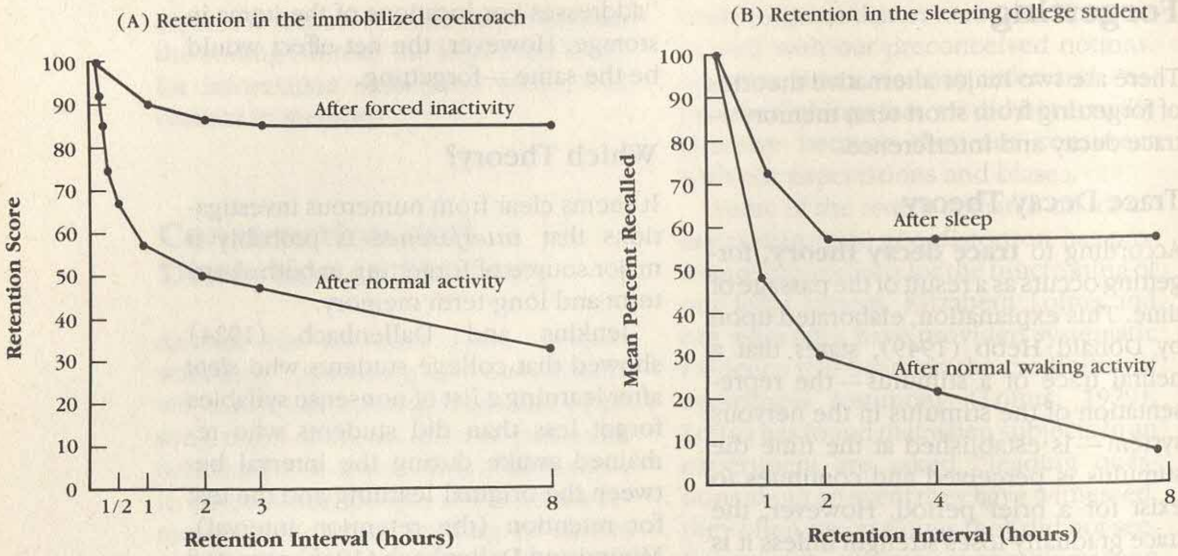


FIGURE 13.7 Results of the Jenkins and Dallenbach (1924) and Minimi and Dallenbach (1946) studies showing effects of inactivity on retention in cockroaches and college students.

day is an important variable in determining how much information is forgotten. Subjects in the "sleep" group of the Jenkins and Dallenbach study had slept at *night.* But other findings show that less is forgotten during a retention interval at night whether one sleeps or not (Hockey, Davies, & Gray, 1972).

Proactive and Retroactive Interference

One type of interference has been attributed to events *preceding* presentation of the items to be remembered. For example, let's say you participate as a subject in a short-term memory experiment. Your task is simply to recall different random seven-digit number sequences on each of ten trials. By the third or fourth trial you begin to confuse some of the digits with those presented on earlier trials. This phenomenon is called **proactive interference;** items are forgotten because of interference from events that preceded the occurrence of those items.

Another type of interference has been attributed to events *following* presentation of the items to be remembered. This kind of interference might occur when you are trying to remember the name of a person you just met at a party. If the host immediately whisks you away to another group and begins new introductions, you may find it difficult to recall the first person's name. This phenomenon is called **retroactive interference;** items are forgotten because of interference from events that followed the occurrence of those items. Test designs for evaluating both types of interference are shown in Table 13.1.

In retroactive interference we know that the *similarity* and *difficulty* of the distracting information can influence the degree of forgetting. For example, if the name of the second person you meet at the party rhymes with the name of the first person you met, you are more likely to confuse the two names than you would be if they had not sounded alike. In general, retroactive interference will be more pronounced when newly encountered distractors are quite similar to those originally stored in memory. Also, you will probably forget more if the distracting items demand a great deal of attention. If you must solve complicated algebra problems immediately following presentation of a list of items to remember, you will probably forget more than if you simply had to recite the letters of the alphabet.

Current knowledge indicates that proactive interference seems to interfere mainly with the process of retrieving items in memory. For retroactive interference it remains unclear whether the distracting events act mainly on stored items or on retrieval processes (Klatzky, 1980). But both proactive and retroactive interference seem to be well established basic principles of forgetting in humans. And they also have been implicated as sources of forgetting in pigeons, monkeys, and dolphins (Thompson & Herman, 1977; Maki, Moe, & Bierley, 1977; D'Amato, 1973).

The Development of Memory

Two things are evident about the development of memory. First, as we grow older we accumulate more information in long-term memory through experience. Second, there is a definite increase in the ability to store and retrieve verbal information, at least until adolescence. But which specific features of the memory system change with age? It is conceivable that at least two aspects of memory may undergo developmental change: the structural components of the memory system, and the functional components.

By structural components we mean the physical capacities of the various memory stores. We would expect that as the central nervous system matures, the neural capacities for storage and retrieval improve. Since a great deal of nervous system development takes place between birth and adolescence, we might expect to see improvement in memory abilities during this time.

The functional components of memory involve the various control processes, such as organization, rehearsal, and retrieval. We would expect age-related changes in the use of any of these strategies to result in changes in memory performance, independent of developmental changes in the structural components of memory, or together with them. Although there is evidence implicating changes in both structural and functional aspects of human memory, the most abundant and clearest evidence involves changes in memory functions.

TABLE 13.1 Experimental Design for Evaluating Proactive and Retroactive Interference

Test for	Experimental Group	Control Group
Proactive Interference	Learn A Learn B Recall B	Rest Learn B Recall B
Retroactive Interference	Learn A Learn B Recall A	Learn A Rest Recall A

Short-Term Memory

Studies of short-term memory nearly always report that older children can recall more items than younger children. There also is evidence that short-term memory capacity declines in the elderly. Much of the evidence to date suggests that some of the improvement or decline in short-term memory span may be understood in terms of the use of effective memory strategies. It is known, for example, that compared to older children, preschoolers are much less likely to code items in terms of their *verbal* characteristics (Brown, 1977; Conrad, 1971), or to rehearse items in short-term memory (Flavell, 1970), However, if induced to name aloud and rehearse items, preschoolers can perform more on a par with adults in tests of short-term memory (Kingsley & Hagen, 1969). These findings suggest that younger children simply do not use effective memory strategies as often as older children, although they are capable of profiting by their use. Thus age-related differences in short-term memory may be due to differences in memory functions. Note, however, that some investigators have found developmental differences in short-term memory that cannot be accounted for totally by the differential use of strategies. Rather, it appears that *speed* of processing information, which may be closely tied to the maturity of the central nervous system, may influence developmental and many other individual differences in short-term memory span (Chi, 1976; Dempster, 1981).

Long-Term Episodic Memory

Age-related differences in the use of organizational, rehearsal, and retrieval strategies exist, though it is not clear how much of the developmental variation in short-term memory span they explain. It is clear, however, that the increasing use of strategies during childhood is correlated with better long-term episodic memory. At about seven years of age, children begin to rehearse one item at a time when presented with a series of unrelated words to remember. And it is not until about eleven or twelve years of age that children tend to rehearse *groups* of words, thus increasing the information content of each rehearsal. As we saw earlier in the chapter, grouping items is an organizational technique that reduces the number of chunks of information that must be stored in memory.

It is interesting that younger children seem to be capable of using more sophisticated strategies than they ordinarily use. If they are taught to organize and rehearse items in groups, and they actually do so, their recall improves (Ornstein, 1977). We might say that younger children have a *production deficiency* with respect to these strategies. That is, they can use successful organizational and rehearsal strategies if *induced* to do so. However, left to their own devices they typically do not produce such strategies (Flavell, 1985). It appears that adults over sixty may also show a production deficiency in organization and rehearsal (Reese, 1976).

Retrieval of episodic information from long-term memory also appears to undergo a developmental progression. Between the ages of about six and eleven there is steady and dramatic improvement in retrieval. Older children are more likely to make use of available retrieval cues to aid their recall. In addition, the oldest children tend to be more efficient, systematic, and exhaustive in their search strategies (Kobasigawa, 1974). Adults over sixty tend to take longer to retrieve items, and seem to profit less from available retrieval cues than younger adults (Anders & Fozard, 1973; Hultsch, 1974).

What accounts for the age-related differences in the memory control processes of organization, rehearsal, and retrieval? Changes in the growth and complexity of the nervous system cannot be ruled out. Another important variable is surely the amount of *knowledge* the rememberer possesses. The ability to group items into distinct conceptual categories requires familiarity with the categories.

An additional kind of knowledge that bears on the use of memory strategies is knowledge specific to the act of remembering itself. This knowledge, which has been called **metamemory,** is the information we possess about our memory powers and limitations, the kinds of strategies that are best suited for different memory tasks, and how to go about executing the strategies. Flavell and Wellman (1977) hypothesize that age-related increases in metamemory should lead to increased use of effective memory strategies. However, research to date suggests that a good metamemory *by itself* is no guarantee that effective memory strategies will be adopted (Cavanaugh & Perlmutter, 1982).

We might also regard memory strategies as behaviors that have been reinforced in the past. Before children enter school they may occasionally use rehearsal, but it is not often demanded or rewarded. However, in elementary school there are suddenly many things to remember—notes and books to be taken home and returned, letters of the alphabet to be memorized, meanings of words to be stored in long-term memory. Children are typically reinforced for such performances by praise and other forms of feedback from teachers and parents. They may also be instructed in rehearsal techniques and reinforced directly for attempts at using them. Increasing demands on memory, reinforcement, and direct training are all factors that may contribute to the increased use of memory strategies by school-age children.

Long-Term Semantic Memory

We know much less about the developmental aspects of semantic memory than of episodic memory. However, it is clear that the content of semantic information grows and becomes elaborated with age, and this results in a greater ability to store and retrieve the *meanings* of things. As children grow older they become better at remembering the content of stories they hear because their memories are more systematically organized around concepts and meanings in long-term memory (Kail, 1979).

Children's networks of semantic relations become enriched and elaborated with increasing age, and this allows them to be more efficient information processors. Education, formal and informal, obviously contributes heavily to the elaboration of semantic information in memory during childhood and adulthood. It is also possible that increasing cognitive abilities in older children, related to maturation and learning, allow them to store memories in a more sophisticated conceptual fashion (Piaget & Inhelder, 1973). There is little evidence that semantic memory declines with age in adults.

A child participates as subject in an experiment on memory.

Human Memory and Evolution

Theory and research related to human memory have, for the past quarter century, centered on information-processing models of cognition. Inanimate information-processing machines have served as a fruitful analogy for describing memory and explaining how it works. However, the cognitive capacities of humans and other animals are rooted in biological evolution, unlike the hardware and software of computers. So although there seem to be many functional similarities between living and nonliving information-processing systems, especially memory systems, an evolutionary perspective may help us understand where the key differences are to be found.

Lachman and Lachman (1979) have attempted a preliminary analysis of human semantic long-term memory—the storehouse of conceptual knowledge—using an evolutionary perspective. Their argument is that current information-processing accounts of semantic memory can be enriched and made more precise by evolutionary considerations. In their analysis they have outlined several general postulates concerning human memory and cognition. These postulates are derived from *three evolutionary generalizations:*

1. "Human Cognition Is the Product of Biological Evolution." Human cognitive capacities, including memory, are rooted in our mammalian, primate, and hominid past. The emergence of placental mammals from reptilian stock probably meant increased selection pressure for parental investment in the young. And as new mammalian species with longer periods of postnatal development evolved, flexible learning abilities in the offspring would have been favored, especially *observational learning abilities.*

> The little mammal who does what his mother does has a good chance of copying adaptive behavior [since the parent has survived long enough to reproduce], reducing the necessity for potentially fatal trial-and-error learning in each new animal. . . . We may further suppose that selection pressures favor *judicious* use of imitation—the later production of the *right* imitative behavior for the situation at hand. To accomplish this, an animal needs relatively analytic representations of information about environmental situations, a sophisticated memory to retain situational and behavioral data, and some range of choice. Some of the most basic human representational and decision-making mechanisms, then, may derive originally from the demands of mammalian life, having evolved to support judicious imitation (Lachman & Lachman, 1979, pp. 138–39).

Although human memory may reflect an investment in learning, common in varying degrees to many mammals, it is also the product of perhaps some sixty million years of primate evolution. In view of this, we might expect human memory and cognition to have become specialized in ways that met the characteristic demands of *primate* living. Lachman and Lachman emphasize the tree-dwelling demands on our primate ancestors, resulting in dramatic refinements in the primate *visual system.* The implication is that human memory may be highly visual in nature because of this aspect of our primate past. We would add that since primate specializations also included *manual* refinements for tree climbing and swinging, and *conceptual* refinements for getting along in social

A tree-dwelling existence requires a relatively sophisticated visual system, including a means of visual-spatial coding in memory.

groups, we might expect that human memory would also reflect these things.

Finally, humans have a unique *homminid* history not shared by other primates. Distinct hominid adaptations included features that supported a terrestrial hunter-gatherer existence, rather than an arboreal one: bipedalism, changed arrangement of teeth, a larger brain relative to body size, and improved capacities for learning, communicating, and maintaining a highly social existence. It seems reasonable to expect that the *unique* aspects of human memory are related to the unique selective pressures associated with the hunter-gatherer way of life.

2. "Human Higher Mental Processes Preceded Western Civilization." Although this is obvious, it is an evolutionary generalization that is not often considered in theory and research related to human memory. Most laboratory studies of adult human memory use tasks that are suitable only for those who can read and write. Thus it is possible that our theories of memory may be culture-bound, and perhaps may apply only to the deliberate memory processes needed for Western *school learning.* Clearly the cognitive abilities we have today are adaptations that originally evolved to support a *preliterate* existence. Thus it seems possible that current theories of memory, to the extent they are based upon "school learning" memory tasks, may not explain fully those aspects of memory common to all members of Homo sapiens.

3. "Human Higher Mental Processes Are a Late Adaptation and Are Not Discontinuous with the Prior Adaptations of the Animals in Whom They Evolved." This generalization means that evolutionary improvements in human cognition are recent, and did not erase previously existing cognitive, motivational, and emotional capacities and tendencies. For example, certain aspects of human emotional behavior may be in part inherited from the earliest mammals. Certainly parts of the brain that play an important role in regulating emotional behavior — structures in the limbic system — are ancient in origin and similar among mammals, as we saw in Chapter 9. Thus we should expect human memory and other cognitive structures to *interact* with more primitive structures. No matter how sophisticated and abstract it is, cognitive processing does not function independently of our phylogenetically older motivational and emotional makeup.

Seven Postulates About Human Memory and Cognition

Based on these three evolutionary generalizations, Lachman and Lachman proposed the following postulates:

"Postulate 1. *Human learning is not unitary.*" This postulate means that humans can store information in different ways and, based upon the evolutionary generalizations already discussed, implies that there is some division of labor among these storage strategies. For example, the type of learning we see in classical conditioning may have evolved mainly to produce memories that support our mammalian motivational and emotional systems. On the other hand, increasingly abstract kinds of learning may have evolved as a result of pressures favoring the production of memories important for social cooperation, hunting and gathering, language, prolonged care of the young, and other primate and hominid adaptations. If this hypothesis is correct, it would be a mistake to think that humans or other primates store different kinds of information in memory in the same way.

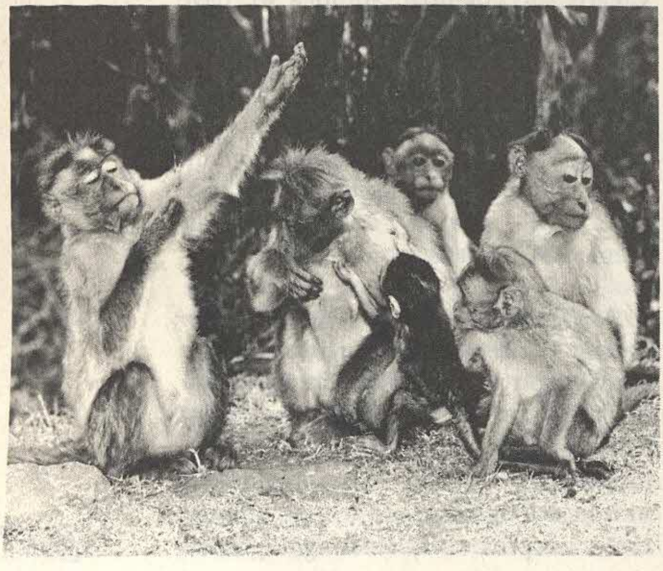
"Postulate 2. *Human cognition reflects the centrality of primate vision.*"

> Ideas that are visually encoded, or whose maintenance and retrieval can be mediated by the visual system, will be relatively easy to process. Visual, or visually mediated, information should be relatively detailed, rapidly encoded, and facilely retained and retrieved. The empirical evidence indicates that it is . . . (p. 143).

Psychological theories of memory might have had a distinctively different flavor if they had used Postulate 2 as a starting point. Most theories of short-term and long-term memory are based upon *verbal* memory experiments, and thus have emphasized the verbal rather than visual content of these storage systems.

"Postulate 3. *The human representational system is not neutral with respect to content.*" Some kinds of information

Existence in primate troops is highly social and therefore requires special cognitive abilities that will allow members to fulfill their needs in a socially acceptable manner.



may be easier to process and remember than others because they have been tied to survival and reproduction in a more fundamental way. For example, concepts concerned with food-getting, sexuality, parenting, cooperation, and aggression may be learned and retained more easily than concepts that are less important to survival.

"Postulate 4. *Human cognition reflects the importance of primate social organization.*"

> A number of conceptualizations are essential to an animal living in a social troop. It must be able to recognize particular individuals and remember its own relationship to them, such as dominance or submission. It must have a self-image, a sense of "place." It must be able to recognize some kinship relations (p. 144).

"Postulate 5. *The origins of human cognition were shaped by emotional factors already present.*" Many speculations are possible here. For example, Sigmund Freud argued that instinctual sexual energy, the *libido,* structured not only the pleasure-seeking impulses of the *id* but also the more rational part of our personality, the *ego.* Thus he believed that there are two separate, but intimately related, kinds of cognitive processes: primary process thinking and secondary process thinking. According to Freud, *primary process* thinking is governed by the irrational, emotional id. It involves fantasy and thinking directed toward the satisfaction of hedonistic impulses, with little regard for reality. *Secondary process* thinking, governed by the ego, is more realistic. However, Freud believed that both kinds of thinking are always present, and that primitive emotional impulses play a large role in determining what we think about, remember, and forget.

Although many of the particulars of Freudian theory are not accepted today, his notions are consistent with Postulate 5. It is unfortunate that the relationship between motivation, emotion, and thought has been largely ignored in contemporary psychological theory and research.

"Postulate 6. *Human logic is nonstandard.*" Contemporary theories of human memory explain it as being organized systematically according to highly logical concepts. However, there are many instances of *illogical* behavior in ordinary day-to-day human reasoning. This kind of cognitive flexibility may have been adaptive, possibly because it led to innovation, or perhaps it is a by-product of cognitive development (see Postulate 7). Flexibility in human cognition is expected from an evolutionary perspective, but this flexibility is largely unexplained by contemporary theories of semantic memory.

"Postulate 7. *The human cognitive system is organized to support a long period of extrauterine development.*"

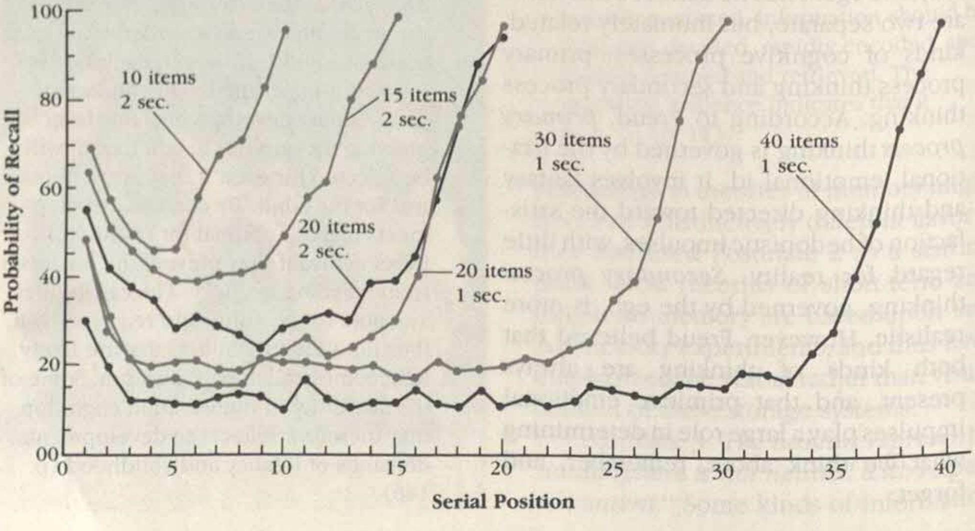
> Semantic memory theorists seldom emphasize that the adult's representations of the world emerge in an orderly way from those of a child. However, evolution is intimately concerned with childhood. Evolutionary developments that favor growing up [survival to adulthood] will be selected for even if they are suboptimal for the adult. By contrast, developments that are optimal for adults will never evolve if they prevent the organism from reaching maturity. The capabilities available to the child, and required by it, thus limit the capabilities that are likely to become available to the adult. Some of the flexibility in human adult cognition may therefore reflect the developmental demands of infancy and childhood (p. 146).

Supplement 1 The Serial Position Effect

One of the best known, most researched, but still least understood memory phenomena is the relationship between the temporal order in which information is received and its retention. Intuitively we might expect the first item in a list to be forgotten most readily (because it is the "oldest"), subsequent items to show progressively more memory strength, and the last (most recent) item to be recalled best. But that is not the way it works: Generally, people are most likely to forget items in the *middle* of a list. This phenomenon is called the *serial position effect,* and the greater recall of the first and last items in a list is referred to as **primacy** and **recency,** respectively. This effect has been observed using short and long lists of items, with visual and auditory presentations of stimuli, and in recall and recognition tasks (Figure 13.8).

Why are we less likely to forget items at the beginning of a list than those in the middle, which are more recently presented? One widely held view is that the primacy effect reflects information that has been transferred from short-term to long-term memory. Recall that short-term memory is a limited capacity system; it can hold only a few items at any one time. The first few items in a list may be *rebearsed* more often or attended to more because they have not exceeded the capacity of short-term memory. They therefore have the greatest chance of being transferred to long-term memory. As additional items in the list are presented, some of them may encounter a "full" short-term memory bin, and thus may be forgotten.

FIGURE 13.8 Serial position curves for free recall of item sequences of various lengths and different presentation rates.



One problem with this theory is that primacy effects have also been observed in *short-term* memory tasks; in such cases these effects cannot be explained in terms of information that has been stored in long-term memory as it is conventionally defined. Another piece of evidence difficult to reconcile with this theory, at least at first glance, comes from studies that have shown primacy effects in children as young as three years of age (Brown, Brown, & Caci, 1981) and in monkeys (Sands & Wright, 1982) and rats (Kesner & Novak, 1982). The reason these data are somewhat troubling is that preschool children and nonhuman subjects show little evidence of planned deliberate rehearsal. However, as we saw earlier in the chapter, rehearsal may not always be a deliberate or planned activity. Thus, primacy in three-year-old children and in rats and monkeys may still reflect rehearsal, but a more automatic kind of rehearsal. It is interesting to note that lesions of the dorsal hippocampus in rats are associated with a *lack* of primacy (Kesner & Novak, 1982). This observation is consistent with a rehearsal explanation of primacy since the hippocampus seems to be involved in the formation of new memories (see Chapter 9), and therefore may influence rehearsal.

A different explanation of the primacy effect involves the notion of *interference.* According to this theory, the initial items are associated with less *proactive* interference than the middle items. (Remember that proactive interference with a given item in memory is generated by information that *precedes* that item during input.) The first item has no proactive interference associated with other items in the list, while the middle items may encounter a great deal of proactive as well as retroactive interference.

A third possible explanation for the primacy effect involves the notion of *temporal distinctiveness.* Perhaps people specially mark the beginnings and ends of sequences of events in memory.

Currently we do not know which of these three explanations of the primacy effect is the correct one. Conceivably each of the three, or some combination of them, could hold under different conditions.

What about recency? The explanation of recency may seem obvious to you, at least intuitively. But scientifically speaking it is still not entirely clear exactly why there is better retention of the last items in a list than of those in the middle. In the past, many psychologists believed that recency occurred because memory traces for the last items did not have a chance to *decay,* at least not as much as items presented in the middle of a list.

Another widely held view, one still entertained by many psychologists, is that recency reflects information still in *short-term memory.* Although there are classic studies that can be cited to support this view (for example, Glanzer & Cunitz, 1966), several lines of evidence are inconsistent with both this theory *and* the trace decay account of recency. Basically, this evidence consists of demonstrations of recency effects even (1) when there are long intervals of time between the last item presented and recall; and (2) when there are opportunities for large amounts of interference between the last item presented and recall. For example, English rugby players were reported to show a recency effect in recalling the particular teams they had played against; the most recent teams played were remembered better than teams encountered earlier in the season. What makes this interesting is that the interval between the last game played and recall involved several days in some cases (Baddeley & Hitch, 1977). Recency in this case certainly reflects something more permanent than relatively fragile short-term memory, which is defined in terms of seconds or minutes.

It also is possible that interference or temporal distinctiveness may explain recency. Recency may occur because the last items in a list receive little or no retroactive interference from other items, or because we simply mark the last item as "last" in memory.

The idea of marking a list of items in terms of "first" and "last" is an attractive explanation because it accounts for both recency and primacy in terms of one basic mechanism — *distinctiveness.* We know that nontemporal distinctiveness can have pronounced effects on the serial position curve. For example, if we circle in red the seventh word (a middle item) in a list of fifteen words printed on a card, it will be recalled better than the words that precede or follow it. This is known as the "von Restorff effect." Presumably the circle around the word makes it stand out from the other words in memory, perhaps by inducing subjects to attend to the word more fully or rehearse it more. If this kind of distinctiveness can alter the normal shape of the serial position curve, then it is conceivable that *temporal* distinctiveness could explain the serial position curve itself.

Incidentally, the typical bow-shaped serial position effect has also been observed in spelling mistakes (more errors are made in the middles of words), in students' recall of lecture material (recall is better for the beginning and end of lectures), and in recall of *spatial* arrays of items (recall is better for items in extreme left and right or top and bottom spatial locations than for those in middle locations). Distinctiveness, temporal or spatial, can account for these phenomena very simply. It is perhaps the most parsimonious theory of forgetting related to serial position of stimuli since it can explain human and nonhuman findings alike (Cornell, 1984), but it is still only a theory. As Murdock (1974) commented, "All things considered, it is difficult to avoid the conclusion that, in some sense, distinctiveness must be involved in these ubiquitous serial position functions. But in what sense we certainly do not know, and much remains to be worked out" (p. 148).

Conceptual Behavior and Development

14

Categories and Categorization

Problem-Solving

Piaget's Theory of Conceptual Development

The Sensorimotor Stage

The Preoperational Stage

The Stage of Concrete Operations

The Stage of Formal Operations

Evaluation of Piaget's Theory

Evolution of Conceptual Behavior

Chapter Preview

This chapter focuses upon the nature and function of *concepts,* and upon *developmental* aspects of conceptual behavior. Concepts are representations of stimuli that are related in some way. Concepts can be concrete or quite abstract. In addition, they can be arranged in a hierarchical order. Thus the concept *tree* can include other concepts, such as *coniferous* and *broadleaf.* When discussing the hierarchical organization of concepts, we usually refer to the concepts and subconcepts as *categories.*

Three different levels of categories have been proposed: the superordinate level, the basic level, and the subordinate level. *Superordinate* categories are the most inclusive and thus represent the highest level of abstraction. *Basic level* categories are contained within superordinate categories. The basic level of categorization is the highest level of abstraction that allows for fairly precise description of category characteristics. Because of this, Eleanor Rosch and others have argued that we typically categorize objects and events in our everyday world at the basic level. *Subordinate* categories are subgroups of basic level categories.

With increasing age, children are more likely to categorize items on the basis of common features, and to use categories of an abstract nature. Preschool children typically use basic level categories to classify items rather than superordinate categories.

Our conceptual knowledge allows us to do more than classify objects in the environment; we can also *solve problems* related to those objects. In order to solve problems, we must first understand them, which involves the use of selective attention. Some solutions to problems seem to arise from a sudden burst of insight, but many problems require the use of deliberate *strategies*. Random search strategies involve trial-and-error attempts to solve problems. Heuristic strategies are more selective and thus are often more efficient ways to solve problems. Past experience can facilitate or inhibit problem-solving. Original and useful solutions appear to result from *divergent* thinking, and are considered *creative* solutions to problems.

Jean Piaget provided a systematic and highly influential theory of conceptual development. Piaget's theory emphasizes that children's concepts change in stages. His four major stages, in order of occurrence, are: sensorimotor, preoperational, concrete operational, and formal operational. At each stage the child shows a conceptual ability that appears distinctively different from and more advanced than that of the previous stage.

According to Piaget, thinking has its origin in the earliest reflexes, sensations, and perceptions of infancy. With each stage, the child's thought processes become less dependent upon the world of concrete objects. The ultimate level is *abstract* thinking, which appears in the formal operational stage.

Progression through the four stages of development is influenced by physical maturation and experience. Piaget believed that children are innately programmed to be curious and to resolve uncertainty through *assimilation* and *accommodation*. To assimilate is to interpret new events in terms of things we already know. To accommodate is to revise what we know in order to understand new events. Accommodation is necessary for children to progress from one stage to another.

Piaget's theory has stimulated a great deal of interest in and research related to children's conceptual processes. However, new discoveries suggest that some aspects of Piaget's theory may have to be revised.

Many aspects of conceptual behavior may not be uniquely human evolutionary adaptations. For example, human and nonhuman primates show many parallels in intellectual accomplishments during infancy. In addition, stimulus generalization, a probable evolutionary precursor to conceptual ability, is widespread in the animal kingdom. Even conceptual awareness may have evolved in nonhuman species, especially the primates, because of its survival value in social settings.

Concepts, loosely speaking, are ideas. More specifically, a **concept** is a *unitary mental representation* of *stimuli* that are *related* in some way. In this sense, a concept is a *generalization*. To say that someone has a *concept* of a tree implies much more than a mental representation of a single tree. It implies that the person knows many of the characteristics typical of all trees.

One way to conceive of concepts is to think of them as *chunks* (groups) of information. In Chapter 13 we saw how chunking items together according to some rule or some relationship among them reduces the burden on memory. Concepts can be thought of as relatively huge chunks of information that provide a great deal of economy in thinking.

Another way to characterize concepts is in terms of information in long-term memory, where information seems to be stored in an associative fashion. Concepts can be seen as *networks* of information, the basic units of *semantic* memory.

Concepts can involve very *concrete*, almost perceptual, information. However, no matter how concrete, concepts are much more than perceptual images stored in memory. To say "I have a concept of a tree" implies that I am aware of the essential properties that specify a tree. Certainly, I know that trees consist of leaves or needles, branches, a trunk, and roots, and I could draw a picture that would be easily recognized as a tree by others. In short, my concept of *tree* contains a good deal of concrete information. But I also know many things about trees that are less concrete. For example, I know that trees are used for lumber and for firewood. Moreover, lumber from some kinds of trees, such as western red cedars and redwoods, is highly resistant to rot, while the best trees for firewood include hardwoods such as birch and maple. I also know that trees depend upon the process of photosynthesis for life and growth, absorbing water, carbon dioxide, and radiant energy to synthesize carbohydrates. This information is quite abstract, but it is part of my concept of *tree*.

Thus a concept is a network of related information, information that can be represented in terms of several different sensory modalities and can vary in level of abstractness.

Categories and Categorization

Often a concept includes other concepts that can be arranged in a hierarchical order. When discussing the hierarchical organization of concepts, we usually refer to the concepts or subconcepts as *categories* or *classes*. Thus the concept *tree* can be considered a category that includes other categories, such as *coniferous* and *broadleaf*, and each of these can be broken down further into different kinds of trees.

Types of Categories

Eleanor Rosch and her associates have made a useful distinction in the classification of natural categories (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). By *natural categories* we mean those that are encountered in our everyday world, as opposed to artificial categories such as geometric figures. Rosch et al. identified three levels of natural categories: the superordinate level, the basic level, and the subordinate level.

Superordinate categories are the most inclusive; they contain the most members. Because of this they represent the highest levels of abstraction. In other words, they are characterized in less definite terms than are the lower-level categories they include. Examples of superordinate categories are *fruit, furniture,* and *vehicle.* In addition to being the most inclusive, superordinate categories share the fewest features with each other. A *feature* of a category simply means a characteristic that all members of the category share. For example, all members of the superordinate category *vehicle* share a functional feature, that of providing transportation.

Basic level categories are subgroups within superordinate categories. Basic level categories within the superordinate *fruit* include such items as *apple, orange,* and *peach.* Those for the superordinate *vehicle* include *car, train, airplane, sailboat, truck,* and *bus.*

In turn, basic level categories include subgroups called *subordinate* categories. For example, the basic level category *car* includes many different kinds of cars—Volkswagens, Fords, Fiats, Toyotas, and so on. Of course, brand names of cars are not the only subordinate categories available for the basic level item *car. Car* could be subordinated according to *many* different dimensions, such as color, size, age, or horsepower (see Table 14.1).

TABLE 14.1 Examples of Attributes for Various Levels of Category Items

Superordinate	Basic Level	Subordinate
Musical instrument	Guitar	Folk guitar
	Piano	Grand piano
	Drum	Bass drum
Fruit	Apple	Mackintosh
	Peach	Cling
	Grapes	Concord
Furniture	Table	Kitchen table
	Lamp	Desk lamp
	Chair	Kitchen chair
Tree	Maple	Sugar Maple
	Birch	White Birch
	Oak	Red Oak

Source: Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976.

Based on the work of Rosch and her associates, it appears that superordinate categories, being much more abstract than the other levels, give us the *least concrete* specification of their members. For example, *vehicle* does little to conjure up a concrete image of a typical vehicle. The lack of precise specification of members of a superordinate category is even more apparent in the case of *animal.* In fact, Rosch et al. found that adults are able to list only a few attributes of most superordinate categories; they can name only a few things that they think all members of a particular superordinate have in common. How many features can you name that would apply to all animals?

In contrast, many more common attributes can be listed for basic level categories. Consider the number of features you can name that would characterize the basic level item *bird.* It is highly likely that you can come up with many more features than you did for *animal.* However, there is not much additional gain in the number of attributes that can be listed when we go from basic level to subordinate level categories. For example, going from *bird* at the basic level to *blackbird* at the subordinate level does not yield as much additional information as going from *animal* to *bird* did. Most people will be able to list one or two more features for *blackbird,* probably relating to color and habitat, than they did for *bird.* Of course, an ornithologist could improve on the feature list for *blackbird* considerably (see Table 14.2 for other examples).

The point is that for most people the basic level category is the highest level of abstraction that allows for fairly precise specification of category attributes. If we go higher, to the superordinate level, we gain in inclusiveness of the category, but the number of features that all members of the category share is reduced. If we drop down to the subordinate level, we may pick up a few additional features shared by all members of the category, but the gain in number of features—that is, information—will be much less than the gain in dropping from superordinate to basic level. For these reasons Rosch has argued that we typically categorize objects and events in our everyday world at the basic level. As Bourne, Dominowski, and Loftus (1979) state:

> The basic level is one at which the organism can obtain the most information with the least cognitive effort. Rosch assumes that categorization occurs to reduce the infinite differences among stimuli to manageable proportion. If so, it is to the organism's advantage both to have each classification as rich in information as possible and simultaneously to have as few classifications as possible. The basic level of classification is a compromise between these two principles. It is the most general and inclusive level at which categories are able to correspond to real-world stimulus structures (p. 208).

Developmental Aspects of Categorization

For nearly half a century developmental psychologists have expended considerable effort on investigating the development of categorization in children. The kind of experimental procedure typically used has been the *sorting task.* Subjects are given a variety of objects, or pictures of objects, to sort into different piles, and are instructed to put items together that belong together. Usually in tasks such as this the items can be grouped into meaningful categories. For example, there may be various kinds of vehicles (car, truck, bus, train), animals (dog, cat, horse, mouse), furniture (table, chair, sofa, lamp), and cooking utensils (coffeepot, saucepan, serving spoon, eggbeater). The various items in the preceding sentence are sorted into mutually exclusive superordinate categories. But a subject being tested in a sorting task would be presented with the items spread randomly on a table.

Results of such sorting studies reveal two general developmental trends. First, preschool and young school-age children are much less likely to group items on the basis of common features than are older children and adults. Rather, very young children often group items on the basis of themes, on the basis of properties that are generally related but not specifically shared, or for other unconventional reasons. An example of a sort based on a theme would be "Car and dog go together because dogs ride in cars." A sort based on properties that are generally related but not specifically shared might be "Kitten and sweater go together because they feel soft." Such groupings have been called "graphic collections" by Jean Piaget and "complex forma-

TABLE 14.2 Number of Attributes Named at Each Category Level

Category	Superordinate	Basic Level	Subordinate
Musical instrument	1	8.3	8.7
Fruit	3	8.3	9.5
Furniture	0	7.0	7.8
Tree	10	11.0	11.5

Source: After Rosch et al., 1976.

tions" or "thematic groupings" by other cognitive and developmental psychologists (Bruner, Olver, & Greenfield, 1966). These groupings are not based upon conventional criteria for classification; that is, they are not based upon common features that define a more inclusive category.

The second trend indicated by developmental research on categorization also highlights differences between preschoolers and young school-age children on the one hand, and older children and adults on the other. When young children do categorize in a conventional fashion, the features they use appear to differ from those used by older children and adults. Younger children tend to base their categories upon perceptual features, such as color, size, and shape, and upon functional features, such as the action properties of objects or the ways objects may be used. For example, if confronted with the task of sorting objects such as those listed earlier, young children are more likely to group together objects that are the same color, or that have similar functional characteristics, for example, "You ride on a train and a horse." As children get older they are more likely to group items according to more abstract superordinate categories (Annett, 1959; Bruner, Olver, & Greenfield, 1966).

This might lead us to assume that younger children, especially preschoolers, may be unable to categorize in a conventional manner. But more recent research suggests that this characterization may not be totally accurate. Apparently the limitation shows up only if *superordinate* level groupings are required in the sorting task. If children are given items to sort at the *basic* level of abstraction—for example, different kinds of cars or dogs or tables or artificial categories, such as geometric forms—then it turns out that even three-year-olds can categorize in an adult fashion (Mervis & Crisafi, 1982; Rosch et al., 1976). It appears that when children are given items which can be classified at a level that is meaningful to them—the basic level—they show competence in categorization. Superordinate groupings, such as those used in the earlier sorting studies, often require a knowledge of relationships among objects that young children may not have acquired.

Problem-Solving

In the first part of the chapter we discussed the nature and organization of concepts, the basic chunks of meaningfully related information stored in memory. We emphasized that concepts are mental representations of stimuli that consist of specific defining features. Because of our conceptual knowledge we are walking, talking mental dictionaries. Present a person with the name of a known concept and he or she will probably be able to discuss its features and its relationship with other concepts.

But our conceptual knowledge is not limited to the structural and functional properties of the stimulus itself. For example, our mental dictionaries contain more information under the concept *chair* than just the features that define the nature and uses of chairs. We also know *rules* for *solving problems* which involve chairs. We know how to sit on a chair, how to pick one up and throw it through a window to escape a burning building, perhaps how to construct or repair a chair. Thus concepts are more than mental representations of external stimuli; concepts contain information necessary or useful for recognizing and solving problems related to those stimuli. It is this aspect of conceptual knowledge that we will now address.

> The solving of problems is a widespread and pervasive human activity. . . . A problem exists whenever we want something (a goal or a result) that is not readily obtainable; that is, a problem exists when the correct response (answer or behavior) is uncertain (Reynolds & Flagg, 1983, p. 232).

Understanding the Problem

In order to solve a problem it is first necessary to understand its various components. It should also be obvious that understanding comes about only if we *attend* to the problem. The attentional process must be *selective;* that is, we need to attend to those aspects of the problem that we recognize as being relevant to the solution of the problem, and to ignore irrelevant information. To illustrate, consider the following problem:

> If an airplane crashed on the border between New York and Connecticut, and just before it hit the ground it was descending at a rate of seven miles per minute, in which state is it most likely that the survivors would be buried?

Attention is the key to understanding this problem, and to solving it. Almost all of the information in this problem is irrelevant to its solution, which is that survivors are not buried—at least, they shouldn't be. In order to solve this problem it is necessary to recognize that the nature of the accident, its location, and the speed of the airplane's descent are all irrelevant pieces of information. Solving the problem involves identification of the contradiction contained in the last four words of the problem statement, and ignoring the preceding information.

It is not always the case that sustained attention to a problem leads to its solution. In some cases doing just the opposite appears to be the best strategy. A "time-out" period in which the problem-solver attends to other things, often referred to as **incubation,** has been considered by some to be an important step in solving problems (Wallas, 1926). Based upon anecdotal (often autobiographical) evidence, it would appear that a period of incubation preceded many great discoveries, contributions, and ideas, including those of Archimedes, Tchaikowsky, and Darwin. An excellent example is found in the writings of the French mathematician Henri Poincaré:

> For fifteen days I strove to prove that there could not be any functions like those I have since called Fuchsian functions. I was then very ignorant: every day I seated myself at my work table, stayed an hour or two, tried a great number of combinations and reached no results. One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come from the hypergeometric series; I had only to write out the results which took but a few hours.
>
> Then I wanted to represent these functions by the quotient of two series; this idea was perfectly conscious and deliberate, the analogy with elliptic functions guided me. I asked myself what properties these series must have if they existed, and I succeeded without difficulty in forming the series I have called theta-Fuchsian.
>
> Just at this time I left Caen, where I was then living, to go on a geologic excursion under the auspices of the school of

> mines. The changes of travel made me forget my mathematical work. Having reached Countances, we entered an omnibus to go some place or other. At the moment when I put my foot on the step the idea came to me, without anything in my former thoughts seeming to have paved the way for it, that the transformations I had used to define the Fuchsian functions were identical with those of non-Euclidean geometry. I did not verify the idea; I should not have had time, as, upon taking my seat in the omnibus, I went on with a conversation already commenced, but I felt a perfect certainty. On my return to Caen, for conscience sake I verified the result at my leisure (From Poincaré, 1913, quoted in Mayer, 1983, p. 44).

Obviously, problems must be understood before they can be solved, and this requires attention, at least initially. Sometimes the solution to a problem comes with apparently sudden insight. In such cases it is difficult to specify the steps involved in arriving at a successful solution. But there are many problems that require a deliberate and sustained effort before a solution is found. Psychologists have identified various *strategies* that can be used to find solutions to such problems, called "search strategies."

Random Search Strategies that involve trial-and-error attempts to solve problems are called **random search strategies.** Random search can be carried out in a haphazard manner or systematically. Consider a problem that beginning chemistry students might be confronted with. Each student is given a test tube containing a blue liquid, and also six other test tubes containing colorless solutions. The lab instructor asks the students to determine which combination of colorless liquids will yield the blue solution. The student who began combining the contents of different test tubes in hopes of stumbling upon the right combination would be using an *unsystematic* random search. On the other hand, the student who assigned a different number to each of the six test tubes, and then proceeded to test *all possible* combinations—1 with 2, 3, 4, 5, 6; 2 with 3, 4, 5, 6; 3 with 4, 5, 6; and so on—would be using a *systematic* random search.

Heuristic Search Problem-solving strategies that are *selective,* not random, are called **heuristic search strategies.** One student may faintly recall reading in his lab manual a week ago that *three* chemicals had to be mixed in order to produce a colored solution, but he can't remember which color. This student might be well advised to begin by testing only combinations involving three chemicals, rather than all possible combinations of the six solutions. This kind of selective search may save a great deal of time and energy if the student's recollection is correct and if the manual reference had been to the color blue. Of course, the student's memory may be faulty, in which case the heuristic would not pay off with a successful solution of the problem. It is the nature of heuristics that they can be extremely efficient problem-solving strategies, but they may not always produce a correct answer. On the other hand, random strategies usually are not very efficient but, in the case of systematic random search, they will always yield a correct solution eventually.

Past Experience and Problem-Solving

Positive Effects Obviously, information we have committed to long-term memory can and does help us solve problems. A person who is illiterate will be unable to recognize problems presented in written form because the meanings of the printed symbols have not been stored in long-term memory. On the other hand, a person who is literate not only in the English language but also in *computer* languages will be able to recognize problems in computer programming that are indecipherable without such knowledge. These examples illustrate the influence of past experience on *understanding* problems. But what we have learned can also aid us directly in *solving* problems. This was demonstrated most clearly in animals by Harlow (1949).

Monkeys were taught which of two objects was associated with a food reward (Figure 14.1). The two objects differed from each other on a variety of dimensions: shape, size, color, complexity, and so on. The same pair of objects, A and B, would be presented over several trials. Underneath one of the objects, say A, the monkey would always find food. Nothing would be found under the other object (B). On each trial the monkey simply had to determine which of the two objects was hiding the food reward. To make things more complicated, A was on the right side of the table for some trials, and on the left side for others. This may seem like a simple problem at first glance, but it is not. Before training, there is no reason for the monkey to expect the food consistently under one of the objects independent of its right or left placement on the table. For all the monkey knows, the experimenter may be alternating the reward from one object to the other on each trial, regardless of right-left location; alternating it from one location to another, regardless of the particular object; or locating it on one side and not the other.

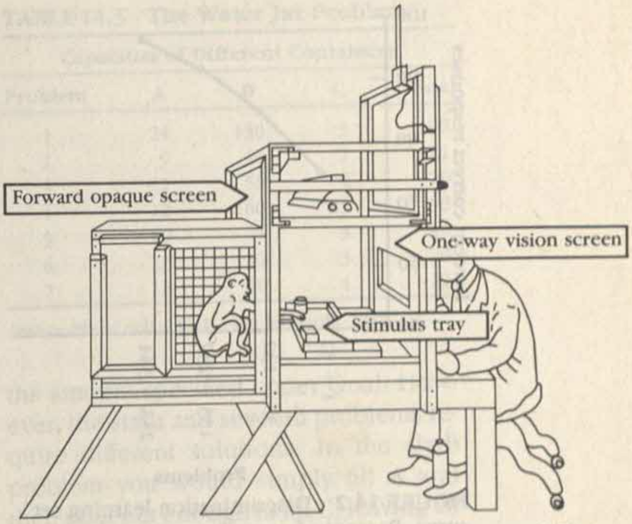


FIGURE 14.1 Illustration of the Wisconsin General Test Apparatus (W.G.T.A.) used to present object discrimination problems to monkeys.

In one experiment Harlow presented each monkey with 344 different pairs of objects—*problems*—to discriminate, and each of these problems was run for several trials. Results of this study showed that the monkeys responded in a trial-and-error fashion on the early problems, acquiring the correct solution only after several trials. However, after experience with about two hundred of these problems, the animals began to solve *new* problems of the same type very quickly. The monkeys appeared to have developed a general strategy for solving object discrimination problems by experiencing many different problems requiring the same general solution. In Harlow's terms, the monkeys formed **learning sets** (Figure 14.2):

> The data indicate that the subjects progressively improve in their ability to learn object-quality discrimination problems. The monkeys *learn how to learn* individual problems with a

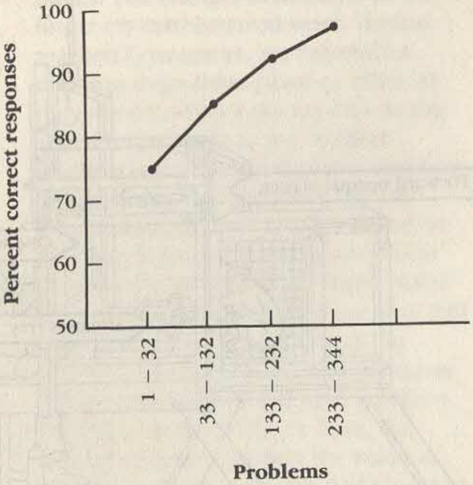


FIGURE 14.2 Discrimination learning set curve. Percent of correct responses by rhesus monkeys averaged over trials 2 through 6 for successive blocks of object discrimination problems.

> minimum of errors. It is the *learning how to learn a kind of problem* that we designate by the term *learning set*. . . .
>
> Before the formation of a discrimination learning set, a single training trial produces negligible gain; after the formation of a discrimination learning set, a *single trial constitutes a problem solution.* These data clearly show that *animals can gradually learn insight* (Harlow, 1949, pp. 390–93).

Harlow's findings (which, incidentally, have been replicated with humans) should be encouraging to students and educators alike. They suggest that initially complex problems can be mastered through training, and that many apparently insightful solutions to new problems derive from previous problem-solving experience. The key to success is that the learner practice solving a variety of problems *requiring similar solutions.*

The monkeys' performance in Harlow's experiments can be characterized as the gradual learning of *win-stay* and *lose-shift* strategies for solving object-quality discrimination problems. The animal learns to *stay* with a particular object if choosing it has produced a reinforcer, and to *shift* to a different object if the first choice is not rewarded. Some researchers have questioned whether learning such strategies takes as much training with different objects as Harlow's results seem to indicate. Specifically, Menzel and Juno (1982) reported that a New World primate—the marmoset—shows evidence of using win-stay and lose-shift strategies related to foraging with *no* training when tested under more natural conditions than were used in Harlow's studies. Though species differences must be taken into account, it is possible that the more impressive strategic behavior of the marmosets may be due in part to the more natural conditions under which they were reared and tested. Menzel and Juno imply that the *gradual* acquisition of strategic behavior shown by Harlow's monkeys may reflect the *regaining* of performance levels that had been inhibited by the unnatural and structured laboratory conditions and by social isolation during testing. It is also likely that Menzel and Juno's animals had considerably more previous experience with foraging and investigatory behavior under natural conditions than did Harlow's laboratory-reared monkeys. Thus, it is possible that the marmosets' strategic behavior also developed gradually, but through *natural* trial-and-error learning rather than through laboratory-structured training. Careful longitudinal observations would be required to settle this issue.

Harlow's learning set is one example of a more general concept called **positive transfer**—learning to solve one problem facilitates, or transfers positively to, the solution of a different problem. Learning to use one version of BASIC, the computer language typically used to program personal computers, will facilitate the learning of a different version of BASIC, or a different computer language, such as FORTRAN. Mastering the trumpet will likely make the trombone an easier instrument to play. Generally speaking, transfer of training is positive when the responses to be acquired are similar to, or compatible with, the previously learned responses.

Negative Effects Past experience may also impede problem-solving performance. Sometimes previously successful strategies actually inhibit the discovery of a successful solution to a new problem. This phenomenon is called **mental set.** A classic example of mental set is the water jar problem (Luchins, 1942). The water jar problem consists of several subproblems presented one at a time to a subject. On each problem the subject encounters a hypothetical situation in which there are three jars, each with a different capacity. For example, jar A can hold 21 quarts of water, jar B 127 quarts, and C 3 quarts. The subject is asked to figure out how to obtain a specified amount of water — say, 100 quarts — using the three jars and an unlimited supply of water. In this particular problem you could obtain the goal of 100 quarts by filling jar B (127 quarts), then filling A from the contents of B, leaving 106 quarts in B. Finally, you could pour water from B into C, empty C, and do the same thing once more. This would leave 100 quarts in B (106 minus 3 minus 3).

Several problems of this kind are presented in Table 14.3. As you can see, the first five all require the same solution — B minus A minus 2C — in order to obtain the amount specified under Goal. However, the sixth and seventh problems require different solutions. In the sixth problem you would simply fill A and then pour out enough to fill C, leaving 20 quarts in A (23 minus 3). The seventh problem can be solved by filling A, filling C, and then pouring both into B to obtain the goal of 22 quarts (18 plus 4).

TABLE 14.3 The Water Jar Problem

	Capacities of Different Containers			
Problem	**A**	**B**	**C**	**Goal**
1	24	130	3	100
2	9	44	7	21
3	21	58	4	29
4	12	160	25	98
5	19	75	5	46
6	23	49	3	20
7	18	48	4	22

Source: Based on Luchins, 1942, in Matlin, 1983.

Interestingly, experimental subjects who work the first five problems successfully tend to experience difficulties with the sixth and seventh. However, control subjects who *start* with problems 6 and 7 have very little difficulty discovering the solutions to these two problems. It is as if the experimental subjects develop an expectation based upon past experience — a mental set — about how to solve all succeeding problems of a similar type: B minus A minus 2C. This set then impedes their ability to discover the more straightforward solutions to problems 6 and 7.

Mental set is an example of **negative transfer;** training or experience with one problem inhibits, or transfers negatively to, the solution of a different problem.

Another way past experience can interfere with problem-solving is through **functional fixedness,** which results when our perception of an object's function keeps us from discovering new ways in which to utilize the object. For instance, someone who perceives that chairs are only for sitting on and is "fixed" on this function of chairs may fail to find other ways of using chairs to solve problems. For example, it may not immediately occur to that person that the chair could be used to break a window in order to escape a burning building, or as a weapon in defense, or as fuel to keep warm. Duncker (1945) provided convincing demonstrations of this phenomenon. In one problem, experimental subjects were given three small cardboard boxes, one containing candles, another matches, and the third thumbtacks. Control subjects were also given three boxes, but they were empty. In addition, the controls received the candles, matches, and tacks, but not in the boxes. The same problem was posed to both groups: find a way to attach a candle to a wall so that the candle burns properly (that is, so that the candle is in a vertical position). The solution is to light a candle, melt some wax onto one of the boxes, atttach the candle to the box, and secure the box to the wall with tacks. As you might expect, the experimentals had a more difficult time discovering the solution than did the controls. Duncker reasoned that placement of the various objects in boxes fixed the function of the boxes as *containers* in the minds of the experimental subjects. As a result, these subjects experienced more difficulty finding other possible functions for the boxes, such as using one of them as a support for the candle that could be attached to the wall.

Creativity and Problem-Solving

Generally, psychologists view **creativity** as a process that produces original and useful solutions to problems. *Original* solutions are those that are novel, distinct, or unique. Certainly Einstein's theory of relativity and Darwin's notion of natural selection would qualify as original solutions to problems concerning the nature of the universe, and of life in one small part of the universe. *Useful* solutions are those that are considered important. The two theories mentioned also clearly qualify as useful attempts to solve problems.

According to some psychologists, creative problem-solving requires divergent, as opposed to convergent, thinking (Guilford, 1967). In **convergent thinking** the problem-solver examines different logically possible solutions with the aim of arriving at a single solution: ideas converge toward a single correct answer. If you arrived at the B minus A minus 2C solution to the first five water jar problems discussed earlier, you were using convergent thinking. In **divergent thinking** the problem-solver explores several different avenues, each proceeding in a different direction, with no necessity of finding one particular solution in the end. The person who considers all of the ways in which a chair might be used would be engaging in divergent thinking.

Psychological tests of intelligence for the most part measure convergent thinking, while tests of creativity usually are measures of divergent thinking. For example, test items measuring creativity often ask the subject to list possible uses for an object, or to generate novel ways of relating two or more objects or words. Although there is some correlation between IQ and creativity, above-average intelligence is not necessarily accompanied by creative potential. Rather, creativity seems to depend more upon special abilities or motivation (MacKinnon, 1962).

Although important strides have been

made toward measuring creativity, we are a long way from indentifying all of the variables that can influence creative problem-solving. Consequently, recommendations for increasing creative thinking are often based more upon intuition and trial and error than upon scientific evidence. One such method, **brainstorming,** began to receive increased attention in business and other group settings in the 1940s. It involves group problem-solving according to certain guidelines (Osborn, 1963). The guidelines are as follows:

1. There should be no criticism of ideas generated by individuals in the group during the initial brainstorming sessions
2. Individuals should be encouraged to propose as many ideas as they want to
3. Unusual or even "wild" ideas should be encouraged
4. Ideas that combine or build upon earlier contributions of group members should be encouraged.

Although little was known about creativity when brainstorming became popular in the 1940s, there is now some evidence that it is effective in stimulating both numerous and valuable solutions to problems (Barron, 1969).

Piaget's Theory of Conceptual Development

The ideas of Jean Piaget (1896–1980) concerning cognitive development have, without a doubt, received more attention worldwide than those of any other developmental or cognitive psychologist. Piaget began formulating his influential theory of conceptual development during the 1920s, and continued to modify and extend his notions until his death. Between 1923 and 1932 Piaget published five books dealing with child thought, language, and moral reasoning. These works were based on research he conducted while director of the Rousseau Institute in Geneva, and brought him instant recognition as an expert on child psychology. His initial publications were followed by hundreds of articles, several monographs, and books, making Piaget one of the most prolific scientists of the twentieth century. His expertise and productivity in the area of developmental psychology are all the more remarkable considering his academic training. Piaget did not take a single course in psychology until after receiving his Ph.D. in zoology (his dissertation dealt with shellfish, phylum Mollusca). Nevertheless, after receiving his doctorate he immersed himself in the study of psychology and gained valuable applied experience in the construction of intelligence tests as well as in clinical psychology.

In addition to his background in biology and psychology, Piaget was widely read in philosophy, and was particularly interested in a branch of philosophy called **epistemology,** the study of the *nature of knowledge.* Piaget was most interested in how we *construct* knowledge from our interaction with the world around us.

Piaget's theory of conceptual development certainly reflects his interdisciplinary background. The focus of the theory, the development of concepts, is of concern to both philosophers and psychologists. His characterization of cognition is biological in nature; he considers cognition to be like a biological structure that grows and changes in an adaptive way. Finally, Piaget's methods for testing his theory represent a combination of techniques used in psychology and ethology.

Piaget's theory consists of four major

TABLE 14.4 Piaget's Stage-Theory of Conceptual Development

Stage	Age	Conceptual Accomplishments
Sensorimotor	Birth-2 years	Development of the object concept; an elementary understanding of causality; mental representation of the environment
Preoperational	2-7 years	Development of the semiotic function; use of intuitive thought
Concrete operations	7-11 years	Development and use of logical thought
Formal operations	11+ years	Development and use of abstract reasoning

stages of conceptual development: the **sensorimotor stage,** the **preoperational stage,** the stage of **concrete operations,** and the stage of **formal operations** (see Table 14.4). Each of these stages is related to, although not determined by, age. The sensorimotor stage lasts from birth until about two years of age, the preoperational from two until seven years, and the concrete operational from seven until eleven years. The formal operational is the final stage, usually manifested during adolescence. Each stage is characterized by a set of conceptual accomplishments; the stage any child is in is determined by the particular conceptual capacities demonstrated by the child, not by the child's age, although the two are usually related.

Before describing each stage, we shall introduce some terms that are important to understand.

Scheme A **scheme** is an *individual* concept or action. Piaget uses the term *scheme* to include internal things, such as mental images, ideas, and rules for solving problems, and external things, such as infant reflexes, voluntary motor behaviors (for instance, reaching or searching for an object), and verbal behavior. Thus *scheme* is a very inclusive category of behavior.

Cognitive Structure A **cognitive structure** is a set of interrelated and highly organized schemes. Thus a cognitive structure is more *generalized* than a scheme. According to Piaget, the first cognitive structure to emerge developmentally is the **object concept,** also called *object permanence.* Piaget argued that a child gradually attains the ability to understand that objects that are out of sight nevertheless continue to exist. This development occurs during the first two years of a child's life. The object concept is considered a cognitive structure because it can be applied to any object that vanishes or is removed from sight. A little girl who realizes that a person who walks into another room continues to exist but is not sure about the status of a hidden toy does not have a cognitive structure of object permanence. She has a *scheme* that reflects object permanence in the case of the person, but the scheme for a hidden toy would not include object permanence. It is only when the schemes are coordinated and generalized that we can infer a cognitive structure. When new cognitive structures are acquired, the child passes from one stage to the next.

Organization According to Piaget, **organization** is an innate tendency that is part of our cognitive system. The function of organization is to interrelate various schemes. The end products of organization are stable cognitive structures. Of course there is no way to prove directly the existence of this tendency, let alone that it is innate. Piaget simply *infers* this functional property from his observation that conceptual behaviors do in fact become more highly organized throughout the course of child development.

Adaptation Another innate tendency described by Piaget is **adaptation,** which accounts for developmental changes in cognitive structures that constitute the four stages of conceptual development. The principle of adaptation operates via two learning mechanisms—**assimilation** and **accommodation.** In order to appreciate the significance of these two kinds of learning, it is important to understand a basic assumption of Piaget's theory: that humans, and many other animals, are innately *curious* about their environments. In essence, what this means is that from birth on we are *motivated* to resolve uncertainties and ambiguities in the environment.

Assimilation and accommodation represent the two basic problem-solving strategies for acquiring information about our environment and ourselves. They are innate strategies for resolving uncertainty. To *assimilate* is to try to deal with a new problem using "old" or familiar strategies (schemes), strategies that have worked to resolve uncertainty in the past. We interpret the new information in terms of information already stored in long-term memory; little change is required on our part to solve the problem. A child who has mastered the rules of long-hand multiplication with two-digit numbers has little difficulty in applying the same schemes to solving new three-digit multiplication problems. This is an example of assimilation.

Sometimes assimilation will not be effective in reducing uncertainty. If applying familiar schemes does not result in finding the correct solution to the problem, *new* schemes are required. When we *accommodate,* we *change* our schemes (concepts, behaviors) in order to understand and adapt to new information. For example, the rules of addition, subtraction, multiplication, and division are essential for solving algebra problems, but they are not sufficient. New concepts are required, such as an understanding of the rules governing equations. When we change our schemes or acquire new ones in the face of a novel situation, we are accommodating. According to Piaget, assimilation and accommodation are *complementary* learning processes; the two work together to form the complete adaptation function.

Equilibration In order to understand Piaget's principle of adaptation more fully, it is important to introduce one additional concept—**equilibration.** To equilibrate is to achieve or maintain equilibrium. Assimilation and accommodation allow an individual to gain or maintain *cognitive* equilibrium. Our heredity gears us to respond with curiosity to novel or changing conditions in the environment. Piaget hypothesized that when events are moderately different from what we have experienced before, this results in a state of cognitive disequilibrium. Automatically, in response to this state, we attempt to assimilate or accommodate or both, in order to equilibrate, in order to resolve uncertainty. Note that too much or too little novelty does not elicit attempts to equilibrate. For example, achieving mastery of the rules of algebra allows us to be challenged by calculus. But if we do not know algebra, an introduction to calculus probably will not cause cognitive disequilibrium; it will more likely be perceived as "noise," because there is nothing familiar about the new subject matter that we can latch onto and build upon. On the other hand, being exposed to a set of algebra problems that we already know how to solve is hardly likely to result in cognitive disequilibrium either.

Major Assumptions of Piaget's Theory Piaget's theory is quite detailed and complex, but the basic working model is quite simple. The major assumptions and postulates are these:

1. Humans are innately programmed to resolve uncertainty (*adaptation*) and to develop coordinated and interrelated schemes (*organization*).
2. Events that vary *moderately* from what we have experienced in the past produce a state of cognitive disequilibrium, and result in attempts to *equilibrate* through *assimilation* and *accommodation.*
3. Equilibration depends not only upon external environmental events interacting with existing cognitive structures, but also upon physical maturation—the level of motor coordination, visual ability, nervous system efficiency, and so on.
4. The result of the equilibration process is the attainment of increasingly advanced cognitive structures, and therefore progression through the four stages of conceptual development.

Decentering Figure 14.3 shows some of the complexities involved in equilibrating to a particular problem. According to Piaget, progress in development is accompanied by an increasing ability to **decenter.** Within the context of the theory, to decenter is to think about things in a more objective or realistic manner. Piaget considers infants almost totally **egocentric** in their perceptions of the world of objects, people, and self. What this means is that infants do not yet have the more realistic concepts possessed by older children and adults. For example, a typical four-month-old has little or no sense of object permanence; an object exists for the infant only so long as the infant maintains sensory contact with it. Obviously, the infant has not yet accommodated his or her perceptions to the real properties of objects. As we mentioned earlier, a fully developed concept of object permanence is not attained until about two years of age. Another way of stating this is to say that it takes nearly two years for the infant to *decenter* with respect to the properties of missing objects.

The process of development involves gradual decentering in many different areas, according to Piaget. The child is increasingly able to go beyond immediate sensory experience, which can be deceiving, and thereby align his or her thinking with reality.

The Sensorimotor Stage

The sensorimotor stage spans the period of infancy from birth to about two years. As far as Piaget is concerned, all human conceptual accomplishments emerge from the earliest sensory and motor experiences of infancy, which he considers the building blocks of concepts and conceptual behavior in general. As the child progresses through the sensorimotor stage he or she is subject to more and more sensory impressions, and develops an increasingly larger repertoire of motor schemes. Gradually the child's schemes become elaborated, differen-

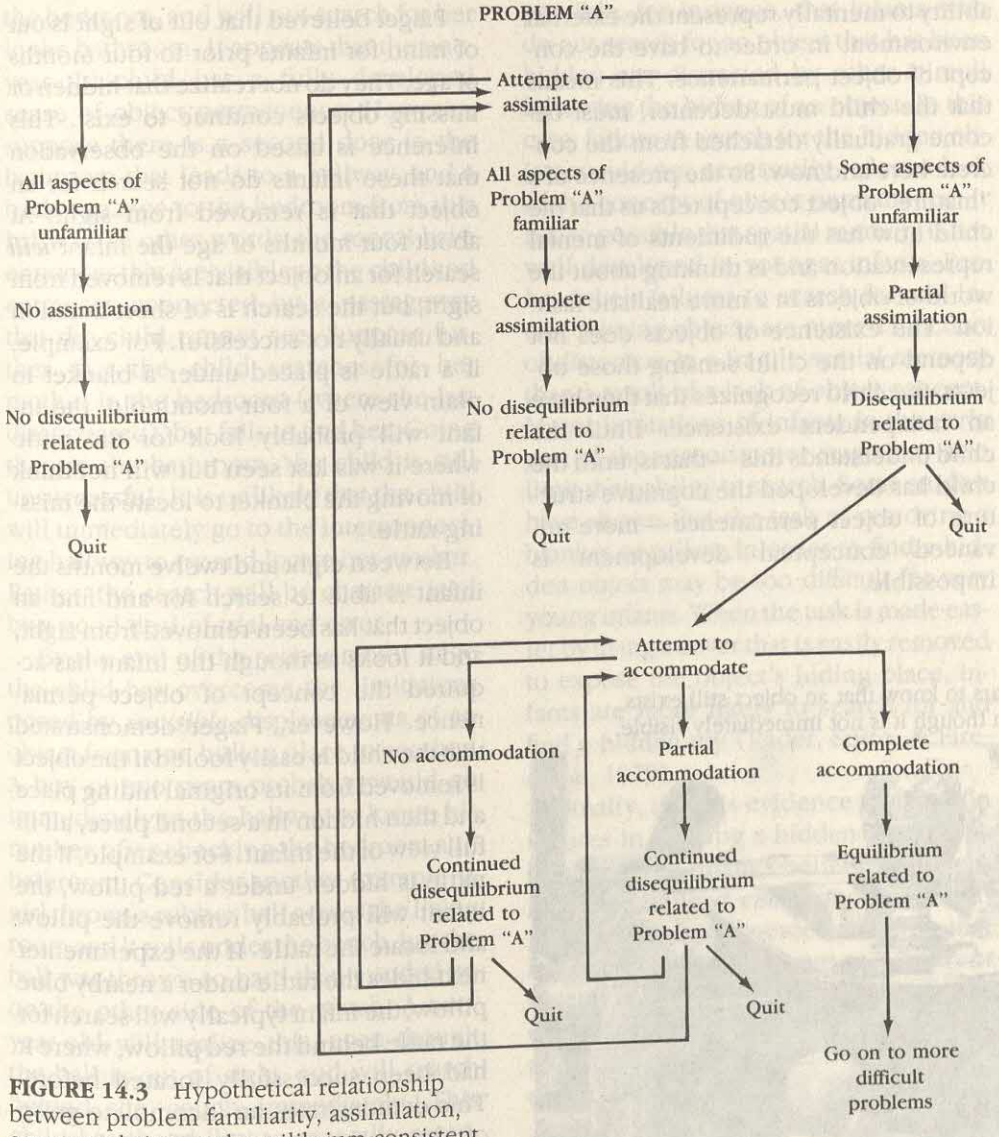

PROBLEM "A"
Attempt to assimilate
All aspects of Problem "A" unfamiliar
No assimilation
No disequilibrium related to Problem "A"
Quit
All aspects of Problem "A" familiar
Complete assimilation
No disequilibrium related to Problem "A"
Quit
Some aspects of Problem "A" unfamiliar
Partial assimilation
Disequilibrium related to Problem "A"
Quit
Attempt to accommodate
No accommodation
Continued disequilibrium related to Problem "A"
Quit
Partial accommodation
Continued disequilibrium related to Problem "A"
Quit
Complete accommodation
Equilibrium related to Problem "A"
Go on to more difficult problems

FIGURE 14.3 Hypothetical relationship between problem familiarity, assimilation, accommodation, and equilibrium consistent with Piaget's theory. Different cognitive actions would be expected depending on how familiar the problem-solver is with problem "A."

tiated, coordinated, and internalized. Near the end of this stage, at about two years, the child develops the ability to represent aspects of the physical environment mentally, to form basic concepts.

Development of the Object Concept

The attainment of object permanence holds special significance in Piaget's theory. The increasing awareness shown by infants of the existence of missing objects is an indicator of their increasing cognitive ability. A child must have the ability to mentally represent the external environment in order to have the concept of object permanence. This means that the child must decenter, must become gradually detached from the concrete here and now. So the presence of a "mature" object concept tells us that the child now has the rudiments of mental representation and is thinking about the world of objects in a more realistic fashion. The existence of objects does not depend on the child sensing those objects; the child recognizes that they have an independent existence. Until the child understands this — that is, until the child has developed the cognitive structure of object permanence — more advanced conceptual development is impossible.

This infant appears to know that an object still exists *somewhere,* even though it is not immediately visible.

Piaget believed that out of sight is out of mind for infants prior to four months of age. They do not realize that hidden or missing objects continue to exist. This inference is based on the observation that these infants do not search for an object that is removed from sight. At about four months of age the infant *will* search for an object that is removed from sight, but the search is of short duration and usually not successful. For example, if a rattle is placed under a blanket in plain view of a four-month-old, the infant will probably look for the rattle where it was last seen but will not think of moving the blanket to locate the missing rattle.

Between eight and twelve months the infant is able to search for and find an object that has been removed from sight, and it looks as though the infant has acquired the concept of object permanence. However, Piaget demonstrated that the child is easily fooled if the object is removed from its original hiding place and then hidden in a second place, all in full view of the infant. For example, if the rattle is hidden under a red pillow, the infant will probably remove the pillow and locate the rattle. If the experimenter next hides the rattle under a nearby blue pillow, the infant typically will search for the rattle behind the red pillow, where it had been successfully located before. This demonstrates an incomplete grasp of the object concept. The infant attempts to *assimilate* the new situation by using a familiar scheme and doing what paid off before.

Once children are about a year old they are no longer fooled by visible displacements of an object from one hiding place to another. A one-year-old who watches her mother go into the bathroom, then come out and go into the bedroom, is aware that her mother is now in the bedroom, and will not search for her in the bathroom. It appears that the one-year-old child has a fully developed sense of object permanence. However, suppose there is a second door in the bathroom that leads to a hallway, and a back entrance to the bedroom from this hallway. In other words, the rooms have entrances that are visible to the child and entrances connected by a passageway that the child cannot see. Suppose further that the child searches for her mother in the bedroom (where she last disappeared), but fails to find her. Going then to the bathroom, the child is still unsuccessful. It is unlikely that the child will immediately go to the interconnecting hallway to try and locate her mother. Rather, the search will be characterized by a good deal of trial and error.

By the end of the sensorimotor stage the child has overcome the limitations posed by *invisible* displacements of an object from one hiding place to another. A boy of two years probably would go immediately to the hallway to locate his mother, after checking the bedroom and bathroom. Consider another example. A girl throws a rubber ball across the living room and it rolls under the couch, but the ball was thrown so hard that it ended up on the other side of the couch. A two-year-old will realize this, even though the ball is out of sight, and will search behind the couch immediately. This child has the ability to mentally represent not only the "invisible" ball, but also its movement and direction while it is under the couch.

Many studies have confirmed the developmental progression in attaining the object concept observed by Piaget (Uzgiris & Hunt, 1975). Nevertheless, it is not clear that infants who *fail* to search for a missing object have *no* idea about the permanence of objects. It is quite possible, for instance, that infants who do not search for an object that has been hidden are distracted by other stimuli following the hiding of an object. In this case, failure to search for the hidden object would not necessarily reflect a lack of the concept of object permanence. It is also possible that spatial memory is not well developed in younger infants. Perhaps their failures to search for and locate missing objects are more a function of distortion in a fragile spatial memory than a result of a lack of object concept. Motor limitations of infants in the early part of the sensorimotor stage may also limit their ability to search. Some studies have shown that the task of removing a blanket or pillow in order to find a hidden object may be too difficult for very young infants. When the task is made easier by using a cover that is easily removed to expose the object's hiding place, infants are more likely to search for and find a hidden toy (Rader, Spiro, & Firestone, 1979).

Finally, there is evidence that certain failures in locating a hidden object may be due to the infant's belief that the object has *changed character*. For example, an infant may perceive a rattle that has been covered by a cup as a *different* object. It is not that the rattle ceases to exist once it is covered, but that the cover and the toy now together become a new object (Bower, 1982).

The Preoperational Stage

During the preoperational stage, Piaget's second stage of conceptual development, the content and process of children's thinking undergo elaboration and change. The preoperational stage is a time when the child acquires what Piaget calls **signifiers**—objects, images, words, or thoughts that stand for other things. There are two classes of signifiers according to Piaget, symbols and signs.

A **symbol** is a mental representation of a perceived aspect of the environment that is concrete and bears a direct resemblance to the object it represents. For example, a visual image of Mother may be elicited when a three-year-old hears his or her mother talking in another room. This would be a symbol, in Piaget's terminology.

A **sign** is a more abstract representation of an object or event. Signs are arbitrary, in that they do not necessarily resemble the things they signify. The most common signs are words or other aspects of language; different languages have very different words or phrases that can translate to the same meaning. Other examples of signs are mathematical symbols or equations.

The symbols and signs — the signifiers — we have been discussing are, for Piaget, the tools of thought. The major task for the preoperational child is to acquire these signifiers, to understand that the signifiers are *different* from the things they signify, that they are merely representations, and to develop an ability to use signifiers in thought and action. Together, these characteristics of cognition constitute what Piaget has called the **semiotic function.**

According to Piaget, development of the semiotic function during the preoperational stage is accomplished primarily through imitation and play. Through *imitation,* the child acquires signifiers. For example, a child learns the word *flower* and what it means by imitating mother saying "flower" and pointing to the rose in the vase. At first the word becomes associated with the flower in a rather automatic fashion. It is simply a response elicited by a stimulus. Later, the word *flower* will begin to operate as a signifier; the child will come to appreciate that the word can be used *to represent* a rose or other flowers. This happens because the child has *internalized* the imitation of the word and what it is associated with. Through this process of internalized imitation, the preoperational child builds up a considerable repertoire of mental signifiers.

It is one thing to acquire a set of tools and to learn the particular situations that require the use of each tool. But it is quite another thing to know how to use each tool properly. A man may own a pipe wrench and realize that it can be used to connect or disconnect pieces of pipe, but he may be stymied when it comes to repairing damaged plumbing, because he has not yet developed any skill in using the pipe wrench. An analogous situation faces the child beginning the preoperational stage of development. A two-year-old is beginning to develop a rather impressive collection of mental signifiers, but it will take practice in using these signifiers before the child becomes skilled in symbolic activities. According to Piaget, this practice comes about through play.

Play may appear to adults to be a natural activity of children in which they express their happiness, work off excess energy, or otherwise keep themselves occupied. But Piaget considered play to be much more than this. Children's play often involves a great deal of *pretending.* Piaget argued that through pretending, children learn that actions, objects, and words can stand for other actions, objects, or words. In other words, children begin to appreciate the function and utility of signifiers through play. Through the *integration* of play with *internalized imitations* children develop the semiotic function.

Intuitive Thought

From about four to seven years the child's thought becomes much more like that of adults, but some striking conceptual differences remain. Of course a preschool child typically has only a small fraction of the information possessed by an adult, or by a ten-year-old, for that matter. But Piaget emphasized that the preschool child's *mode* of thought also differs from that of an older child or an adult. Specifically, the child's thinking is not yet completely logical; Piaget characterized it as *intuitive*.

For Piaget, intuitive thinking is thinking that is not guided by a systematic logic, but it is not unintelligent behavior either. It is simply the highest form of intelligent behavior available to the child in this stage. It might best be considered a rule-of-thumb kind of thinking. Preoperational children have acquired a number of different rules for solving problems in their environment. They know, for example, that one glass contains more chocolate milk than another if the milk in one is at a higher level than the milk in the other. How do they know this? Because they have formed a simple rule: "The higher the level of liquid in a container, the more liquid there is." Preoperational children may not be able to verbalize such a rule, but their behavior can be understood in these terms.

Although intuitive thinking may solve many of the child's less complicated everyday challenges, it has some serious limitations. This is readily seen if we return to the problem of deciding who has more chocolate milk. If one child's glass has a smaller diameter than another child's, an accurate determination of who has more milk will require more information than the intuitive rule can supply. It requires understanding that the smaller-diameter glass must have a higher level of liquid for it to contain the same amount as the other glass. However, according to Piaget, the preoperational child does not use this type of reasoning. This is most apparent in Piaget's tests of **conservation** ability, the ability to recognize the stability of a quantity, even though it undergoes changes in perceptual configuration.

A classic test of conservation ability involves the transfer of liquid from one container to another of a different size. The test begins by having a child make sure that two identical beakers contain equal amounts of water. Then the examiner pours the contents of one of the beakers into a container of a different size, such as a cylinder that is taller and of smaller diameter than the beakers. Of course, the level of liquid reaches a higher point in the cylinder than in the beaker. The examiner then asks the child if there is more water in the cylinder, more in the beaker, or if there is the same amount in each. Preschool children often answer incorrectly that there is more water in the cylinder because the water level is higher. This suggests that these children are using a rule to solve the conservation problem, but are not using a *logical* analysis.

Logical reasoning requires flexibility of thought and an ability to adopt different perspectives, or to consider simultaneously the different dimensions of a problem. In Piagetian terms, the child must develop reversibility in thinking patterns, and must decenter.

In the context of the conservation-of-liquid problem, **reversibility** means that the child is able to mentally reverse or undo what has taken place; if water is poured from a beaker to a cylinder, the child is able to mentally reverse the operation. **Decentering** means that the child is able to consider changes in *both* of the relevant dimensions in this task—the level of liquid and the size of the container—in order to solve the problem. According to Piaget, reversibility of thought and decentering are not part of the preoperational child's repertoire; they do not become cognitive structures until the next stage, called concrete operations.

Note, however, that a number of investigations have attempted to establish conservation ability in preoperational children. There are now several independent studies which show that it is possible to *train* children as young as three or four years to solve conservation problems correctly (Brainerd, 1978). One implication of such studies is that conservation does not require *new* cognitive structures (Daehler & Bukatko, 1985). Another possibility is that the cognitive structures necessary for conservation begin to develop earlier than Piaget had imagined, and that these structures can be modified through training. But it is also possible that preschoolers who have been trained to conserve do so for reasons that are different from those of older, concrete operational children. For example, the cognitive structure of *reversibility* of thinking may still be lacking in preschool children, even though they have been taught to conserve. Instead of mentally undoing what the examiner has done in the conservation task, the trained preschoolers may simply have acquired a *verbal* concept that nothing has been added to or subtracted from the quantity. If this were the case, the conservation training studies could be viewed as inducing a *superficially* concrete operational performance in preschool children based upon *preoperational* cognitive structures.

The Stage of Concrete Operations

Operational thought is logical reasoning. For Piaget, operational thought is acquired and elaborated during the stage of concrete operations, and it is built upon the semiotic function of the preoperational stage, just as the accomplishments of that stage are an outgrowth of the internalized actions of the sensorimotor stage.

Children in the concrete operational stage display the abilities that were missing in the preoperational stage. Specifically, they show reversibility of thought processes and they become increasingly decentered. Because of this they are able to acquire several important sets of concepts. We will focus on three of these: conservation, relations, and classification.

Conservation

Children in the stage of concrete operations can solve problems involving the conservation of liquid, discussed earlier. Piaget also observed children's performances in other kinds of conservation tasks and found that their problem-solving ability *generalizes* to a number of different situations during the concrete operational stage. In addition to problems with liquids, children can solve conservation problems involving *number, substance,* and *weight* (Figure 14.4).

Relations

The kinds of relational concepts Piaget investigated are *ordinal* relations, the "greater than/less than" relationships so important in mathematics and measurement. Piaget's tasks for assessing the

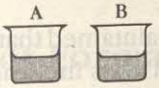
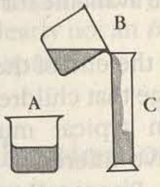
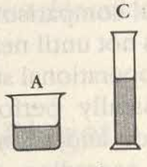
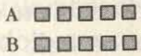
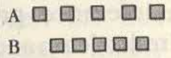
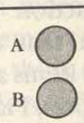
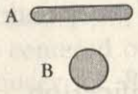
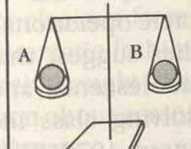
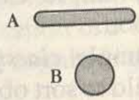
Conservation Task	Question 1	Preoperational Answer	Concrete Operational Answer	Transformation	Question 2	Preoperational Answer	Concrete Operational Answer
Liquid (e.g., water)	 "Equivalent amounts?"	"Yes."	"Yes."	 Container shape is changed.	 "Equivalent amounts?"	"No."	"Yes."
Number (e.g., blocks)	 "Equivalent numbers?"	"Yes."	"Yes."	Row "A" is lengthened.	 "Equivalent numbers?"	"No."	"Yes."
Substance (e.g., plasticene)	 "Equivalent amounts?"	"Yes."	"Yes."	"A" is rolled into a sausage shape.	 "Equivalent amounts?"	"No."	"Yes."
Weight (e.g., plasticene)	 "Equivalent weights?"	"Yes."	"Yes."	"A" is rolled into a sausage shape.	 "Equivalent weights?"	"No."	"Yes."

FIGURE 14.4 Examples of different kinds of conservation problems, and typical responses to such problems by preoperational and concrete operational children.

development of relational concepts involved seriation, multiple seriation, and transitive inference.

In a typical *seriation task* the child must rank order a set of sticks, for example, in terms of one dimension, such as length. In a *multiple seriation task* the child must order items along two or more dimensions—for example, according to length and weight. The *transitive inference task* is the most abstract and difficult of the three relational problems. A transitive inference problem might go something like this: The child is given two sticks, A and B, that differ in length, and is asked to tell which is longer. Next, stick A is taken away and the child is given stick B and another stick, C, and again asked for a judgment about comparative length. Then the child is asked, without being shown stick A again, to tell which is shorter, A or C. The child must make an inference, because not all sticks are available for a perceptual comparison.

It is not until near the end of the concrete operational stage that children can successfully perform typical multiple seriation and transitive inference problems, according to Piaget. However, some research has shown that even five-year-old children can solve certain transitive inference problems if they are required to learn and remember the original relations between A and B (Bryant, 1974). This suggests that Piaget may have underestimated some of the basic abilities of preoperational children.

Classification

As was the case with relations, Piaget used three tasks for studying the development of classification skills: classification, multiple classification, and class inclusion.

A simple *classification task* requires the child to sort objects into mutually exclusive categories. For example, airplanes, cars, and trucks go in one pile; birds, dogs, and cats go in another. In the *multiple classification task* the child must further subdivide the categories. For example, in the "vehicle" category, red trucks and red cars are placed in one pile, and black trucks and black cars in another. In the *class inclusion task* the child must demonstrate knowledge that items can be categorized at various levels of abstraction, and that higher levels of classification include the lower levels. For example, a child may be given a number of wooden beads, some white but the majority brown. The child is then asked, "Are there more brown beads or more wooden beads?" A correct answer — that there are more wooden beads — implies that the child recognizes two classes of beads, brown and white, and that together these two classes form a larger and more inclusive class, that of wooden beads.

Piaget maintained that multiple classification and class inclusion skills should be present by the end of the concrete operational stage. His observations led him to conclude that preoperational children were unable to do even the simple classification task. We have already seen evidence, however, that even three-year-olds can classify items at the *basic level* of abstraction. In addition, many studies report that *some* preschoolers can categorize items at the superordinate level. Once again, Piaget may have been too conservative in assessing the preoperational child's skills. There is also a difficulty with possible *overestimation* of the concrete operational child's skills. Some studies suggest that many older children, adolescents, and adults have difficulty solving class inclusion problems (Brainerd, 1978; Winer, 1980).

Concrete operational thought is a significant advance over preoperational thought, in that it is logical. Thinking is no longer bound by the rigidity of intuitive reasoning. However, there are still limitations. One of these is suggested by the term *concrete.* The child in this stage can use operational reasoning successfully when it is applied to concrete physical objects. This does not mean that objects must be present on the table for a child to reason logically, but such reasoning is more easily applied to concrete things than to those that are abstract. For example, a ten-year-old child may have less difficulty with a transitive inference problem formulated in terms of sticks or people than with one that consists only of symbols. Another limitation associated with concrete operational thought is that it is not very systematic. A child in this stage is not likely to consider all of the logically possible solutions to a problem.

The Stage of Formal Operations

For Piaget, the apex of cognitive development is the attainment of formal operations during adolescence. The formal operational individual has overcome the concrete limitations of the preceding stage, and is much more systematic in approaching problems. A person in formal operations can think and reason on an entirely verbal level. For example, a formal operational individual can reason *hypothetically,* and can entertain very different (even opposing) premises and yet deduce conclusions from them in a logical and systematic fashion. It is formal operational thought that allows a person to reason about reasoning itself, according to Piaget.

Formal operations turns out to be the most variable of all stages, and it appears to be highly related to level of education. Formal operational thought is rare in nonindustrialized cultures where there is little emphasis on formal education. Indeed, even within industrialized societies there is much individual variation in this level of reasoning. People with more education, especially scientific and mathematical education, are more likely to show evidence of formal operations. But even education is no guarantee. A scientist or mathematician may show a good deal of formal operational logic when writing or defending a scholarly paper, but may deal with marital and family problems in a characteristically *preoperational* fashion. Formal operations may be necessary for sophisticated forms of conceptual analysis and reasoning, but it is clearly not an *inevitable* outcome of development.

Evaluation of Piaget's Theory

Although Piaget's account of conceptual development has been the dominant cognitive-developmental theory for many years, some psychologists have been critical of the theory, and have argued that it is in need of revision (Brainerd, 1978; Ginsburg & Koslowski, 1976). Major criticisms have centered on four issues: (1) the adequacy of Piaget's *methods;* (2) Piaget's *interpretation* of children's failures on his tasks as a *lack of cognitive* competence; (3) Piaget's insistence that cognitive development is *discontinuous,* or stage like; and (4) the lack of precise specification of a *mechanism* that accounts for cognitive growth.

Methodology

Piaget's methods of observation have been attacked on the grounds that they are too subjective, and that they sometimes require responses that are difficult for young children to perform for reasons other than a lack of cognitive competence.

There is no question that Piaget's tasks for assessing conceptual development are less objective than traditional tests of intelligence. They allow for much more flexibility on the part of the examiner, who can vary instructions and evaluate responses far more than administrators of traditional intelligence tests do. Such flexibility is likely to lead to inconsistency in observation from observer to observer—in other words, low reliability. In addition, Piaget inferred a great deal about the presence or absence of cognitive structures based upon performance in these tasks. Some psychologists, particularly those with a more behavioristic bent, feel uncomfortable about the complicated mental constructs Piaget used to explain his observations.

In some cases, infants and young children seem to be "penalized" by certain Piagetian tasks. We have already mentioned Rader, Spiro, and Firestone's experiment (1979), which suggested that young infants' lack of physical-motor coordination may impair their ability to show how much they know about object permanence. It has also been argued that some of Piaget's tasks bias against preschoolers because they demand a relatively high level of verbal ability, a level that preschool children typically do not show. For example, preschoolers may interpret the conservation task instruction differently than older children do (Donaldson, 1979).

Interpretations

As some psychologists see it, a major difficulty with Piaget's theory is the assumption that failure to respond appropriately in a Piagetian task necessarily means the child lacks a particular cognitive structure: lack of response equals lack of cognitive competence. A good deal of research, some of which was cited earlier, questions this assumption, particularly in regard to the preoperational stage of development (Gelman, 1978, 1979). Studies have shown that it is possible to modify conservation, relations, and classification tasks in ways that are likely to produce more "mature" performance in children who fail the traditional tasks. For example, three- and four-year-old children generally do not solve conservation problems involving *number* when a large number of stimuli are used, but are more likely to do so with few stimuli. In a conservation-of-number task the examiner shows the child several identical objects (such as eight wooden blocks) placed in a row or some other arrangement, and the same number of these objects in another arrangement. Typically, two rows of blocks are lined up side by side, and the child ascertains that there is the same number of blocks in each row. Then the examiner "stretches" one row so that it is longer than the other. Now the child is asked, "Which row has more blocks; your row, my row, or do we both have the same number of blocks?" With eight blocks, three- and four-year-olds would likely have problems, and claim that the "longer" row had more blocks. But using only four blocks in this task increases the likelihood that even these young children would answer correctly.

Other studies have shown that preschool children are perhaps not as egocentric in their thinking as Piaget suggested. Piaget based his conclusion in part on preschoolers' performance in the "mountain problem." In this task the child must indicate how the particular arrangement of the three mountains looks to someone seated in another place at the table. In order to do this the child must be able to imagine the visual perspective of the other person. In fact, Piaget found relatively few children younger than school age who could respond correctly in this task. Usually the younger child indicates that the visual array appears to others as it appears to him or her. But more recent investigations have shown that preschoolers are more likely to correctly identify the visual scene others perceive if stimuli that are more distinct and meaningful to the child are used, such as three different dolls or toys (for example, Borke, 1975). It is possible that young children respond incorrectly in the mountain task because of lack of interest in and attention to the stimuli, or because they get confused when the three stimuli are identical. These and many other studies suggest that preschool children may *know* more than they can *show* in the standard Piagetian tasks.

Discontinuities in Development

Piaget believed that cognitive growth is both continuous and discontinuous. Specifically, he theorized that development *within* each stage is best characterized as continuous and incremental, and *between* stages as discontinuous and qualitatively distinct. But it can be argued that this distinction is somewhat arbitrary and lacks parsimony. After all, what we actually observe is a fairly continuous developmental progression in most areas of cognition that Piaget discussed. Two-year-olds do not suddenly show the concept of object permanence with no previous indications. Rather, development of the object concept proceeds gradually. Likewise, children do not suddenly show us evidence of well-integrated and generalized ability to grasp conservation problems; their conservation performance becomes increasingly more stable and *gradually* generalizes to different situations. Thus Piaget's insistence that differences in cognition between one stage and another represent differences in *kind,* rather than in *degree,* may be unwarranted.

The Mechanism for Cognitive Growth

Although Piaget argued that biological maturation and experience are both necessary for normal cognitive development, he was not very precise about the amount or kinds of experience required. For example, what role does visual stimulation play in developing the object concept? And how important is formal education to the development of concrete and formal operational thought? Also, he did not indicate exactly *how* experience contributed to the acquisition of various cognitive structures, other than in the very general terms *assimilation* and *accommodation.* Clearly, Piaget devoted most of his effort to *describing* rather than explaining the kinds of concepts and modes of reasoning children develop, and the ways these change with age.

Criticisms of Piaget in Perspective

The criticisms we have described do not "debunk" Piaget's theory. Many replication studies, using methods more rigorous than Piaget's, have generally confirmed the patterns described by Piaget. Thus the *descriptive* aspects of the theory are in most respects satisfactory. And it is possible that many criticisms involving Piaget's *interpretations* could be reconciled within the present theoretical framework. For example, even though preschool children have demonstrated surprisingly mature conceptual ability when the tasks are made simpler, the fact remains that they do not perform as well as older children on the standard Piagetian tasks. A four-year-old may be able to conserve number or to take the perspective of another under certain task conditions, but not under others. A nine-year-old, on the other hand, is able to conserve number regardless of the number of stimuli, and to adopt the perspective of another under a wide variety of conditions. The younger child has some of the *elements* of these concepts, but the older one has the concepts. As long as this developmental distinction is preserved, demonstrations of task-specific competence in preschoolers do not contradict Piaget's theory. Rather, such demonstrations enrich the theory by identifying the positive accomplishments of the preoperational child, and by emphasizing certain continuities in conceptual growth.

To use Piaget's terminology, it would seem that his theory is currently in a state of disequilibrium. Certain research findings that seem critical of the theory undoubtedly can be assimilated into the present theoretical structure, but the theory may have to accommodate to others.

Evolution of Conceptual Behavior

Are concepts and conceptual thought unique human evolutionary adaptations? Both affirmative and negative answers to this question have been offered. If we include spoken language concepts, then it seems clear that these are distinctly human characteristics (see Chapter 18 for a discussion of the evolution of language). But what about nonlinguistic concepts? At least one psychologist has argued that the concepts and skills that are developed during the sensorimotor stage of infancy are not unique to humans, but represent the evolutionary heritage of primates in general:

> The ethological, comparative evidence suggests that we share with at least the great apes a primitive form of infant intelligence. The homologous, intelligent behaviors of infant apes and humans strongly suggest common origins in our primate past. During the first 18 months of human life there are few intellectual accomplishments that are not paralleled in nonhuman primates, particularly the apes. Both develop object concept, imitation, spatial concepts, cause-effect relations, and means-ends reasoning. In brief, both young apes and young humans become skillful, practical experimenters (Scarr-Salapatek, 1976, p. 182).

There are probably elements of conceptual behavior found in older children and adults that also have prehuman evolutionary origins. After all, concepts are generalizations, and the ability to generalize a response to stimuli that are similar in some dimension may have been the evolutionary precursor of the ability to form concepts. Stimulus generalization can be observed in a wide variety of animal species, from protozoans to humans, suggesting that the ability to generalize had significant survival value, even for very early forms of animal life. So it would seem that the basis for concepts and conceptualizing—the ability to generalize the same response to similar stimuli—is not unique to humans or primates as a class; it is well established throughout the animal kingdom. Much of the survival value of stimulus generalization is probably related to the *economy* of generalized responding. Responding to *classes* of stimuli, as opposed to each and every variation the senses detect, reduces the number of individual units of information that must be processed. For various species, then, stimulus generalization means that not as much time and energy has to be expended in learning about the environment, in recognizing food and other resources, in capturing prey or avoiding predators, or in responding appropriately to social situations.

Awareness and understanding of the *relations* among members of a given conceptual category or class probably have had a much more recent evolutionary history than stimulus generalization, but perhaps not a uniquely *human* history. We have seen that the differences in certain conceptual behaviors between humans and chimpanzees are not as great as was once imagined. This has been demonstrated in the chimp sign language training studies (Gardner & Gardner, 1969), and has been documented in chimps in their natural habitat (van Lawick-Goodall, 1971). Chimps also appear to share certain abstract problem-solving skills with humans (Premack, 1983). Considering these similarities, it would seem that selection pressures for improved conceptual abilities operated on *nonhuman* as well as human primates.

Some scientists have speculated that the need to adjust to highly specialized group living may have been more of an evolutionary catalyst for improving conceptual skills than the intellectual demands of gathering food and warding off predators (Leakey & Lewin, 1977). Nowhere in the animal kingdom are the demands and pressures of organized social living more intense and complicated than among primate societies, particularly human societies.

> Intelligence is undoubtedly required for an animal to learn how to exploit the resources of its physical environment. But this does not match the skill demanded to operate successfully in the complex mercurial social milieu of group living: the location of a particularly fertile food source is soon placed in a mental map of the region; dealing with individuals whose reactions to the same event are variable depending on a myriad of circumstances is, however, much more demanding. . . . the creative intelligence that a few million years ago enabled our ancestors to shape specific implements out of lumps of

We share several features of conceptual behavior and development with nonhuman primates.

> stone, and that today has opened up the possibility of interplanetary travel, is rooted in the same social intelligence, whose function is to mitigate the potential friction of group living. We *need* to be intelligent in order to thrive in groups; and we *use* our intelligence to be inventive (Leakey & Lewin, 1977, pp. 189, 190).

The message here is that human conceptual skills may have originated as an adaptive response to *primate* social living, in which case similarities in conceptual behavior between humans and other primates should be expected. Of course our prehuman and human ancestors, as hunter-gatherers, caregivers, and food sharers, faced an even greater need for social cooperation and organization than other primates. The hunter-gatherer way of life, the advent of tool construction, and the emergence of language and culture all undoubtedly contributed to the differentiation of human conceptual behavior from that of other primates (Crook, 1980). Those who were best able to learn, understand, and manipulate new and increasingly sophisticated concepts were the most successful, and ultimately controlled the planet. It will be a bitter irony indeed if the unsurpassed conceptual prowess of humans, rooted in the need for social harmony, ultimately leads to our undoing through continued manipulation and exploitation of each other and proliferation of increasingly sophisticated tools capable of destroying life as we know it.

In everyday [illegible] to mind parties or other gatherings of [illegible] usually associated with pleasant and relaxing times, a spirit of [illegible] love, and sharing and cooperative behavior. These ideas are close to what is called *prosocial behavior,* which is discussed in Chapter 16. However, the [illegible] as used in psychology and biology includes [illegible] related to *actual or potential encounters between individuals.* These may be positive or *negative,* beneficial or harmful. But they are a part of our existence with other humans, and the existence of other animals with members of their species.

There is no doubt that social interactions are very important in the lives of social animals. [illegible] dramatic illustrations of this are the experiments in which [illegible] were raised in total social isolation. As we saw in Chapter 6, these animals display some very bizarre behaviors, characterized mainly by inappropriate activities in social situations.

Even monkeys raised with a nonliving "surrogate mother" display problems in social development. Those raised with a *stationary* fur-covered object show impairments in social behavior at ten months of age. When approached by humans they cling to the surrogate, moving around to the side away from the intruder. In addition, these monkeys frequently bite themselves, or sit rocking back and forth when alone. Monkeys raised with *moving* inanimate surrogates only occasionally show these behaviors, and those raised under normal conditions do not show them at all. Monkeys raised by their own mother, or even by a substitute monkey mother, show the sort of behavior you have probably seen at the zoo or on TV: active, playful, exploring, normal young monkey behavior.

For ethical reasons isolation experiments are carried out only with nonhuman subjects, and therefore the role of social interaction in human behavior and development is not as clearly understood as it is in certain other primates. Nevertheless, anecdotal and observational evidence from studies of humans is generally consistent with data from the experimental study of other primates. For example, a six-month-old human child who has had normal interactions with its

Social Behavior

Chapter 15 Biological Foundations of Social Behavior and Culture

Chapter 16 Prosocial and Agonistic Behavior

Chapter 17 Affiliation, Bonding, and Sex-Related Behaviors

Chapter 18 Communication and Language

UNIT VI

In everyday usage the term *social* often brings to mind parties or other gatherings of friends or relatives. Such occasions are usually associated with pleasant and relaxing times, a spirit of friendship or love, and sharing and cooperative behavior. These ideas are close to what is called *prosocial behavior,* which is discussed in Chapter 16. However, the term **social behavior** as used in psychology and biology includes *all* behavior that is related to *actual* or *potential encounters between individuals.* These may be positive or negative, beneficial or harmful. But they are a part of our existence with other humans, and the existence of other animals with members of their species.

There is no doubt that social interactions are very important in the lives of social animals, including humans. The most dramatic illustrations of this are the experiments in which rhesus monkeys were raised in total social isolation. As we saw in Chapter 6, these animals display some very bizarre behaviors, characterized mainly by inappropriate activities in social situations.

Even monkeys raised with a nonliving "surrogate mother" display problems in social development. Those raised with a *stationary* fur-covered object show impairments in social behavior at ten months of age. When approached by humans they cling to the surrogate, moving around to the side away from the intruder. In addition, these monkeys frequently bite themselves, or sit rocking back and forth when alone. Monkeys raised with *moving* inanimate surrogates only occasionally show these behaviors, and those raised under normal conditions do not show them at all. Monkeys raised by their own mother, or even by a substitute monkey mother, show the sort of behavior you have probably seen at the zoo or on TV: active, playful, exploring, normal young monkey behavior.

For ethical reasons isolation experiments are carried out only with nonhuman subjects, and therefore the role of social interaction in human behavior and development is not as clearly understood as it is in certain other primates. Nevertheless, anecdotal and observational evidence from studies of humans is generally consistent with data from the experimental study of other primates. For example, a six-month-old human child who has had normal interactions with its mother, such as holding, rocking, and playing, can sit up, hold its head steady, and reach out and grasp objects offered to it. However, many institutionalized infants of the same age who have had a minimum of such contacts with adults perform none of these actions.

Although some effects of social deprivation may be permanent, many others can be reversed or reduced. This appears to be true of humans as well as monkeys. The major "therapy" for effecting this change is repeated experience with the very thing that was missing during early development — interaction with others. Our behavior and well-being appear to depend heavily on our interactions with others.

The four chapters in this unit address various aspects of social interactions, including descriptions of some of the major kinds of social behaviors that humans engage in, as well as possible psychological and biological reasons for these behaviors.

15

Biological Foundations of Social Behavior and Culture

Behavioral Similarities

Social Organization and Fitness

Culture

Supplement 1 Habitat Selection

Chapter Preview

Social behavior includes all behavior that is related to actual or potential encounters between individuals. Like other behavior, it is a product of biology and culture acting together. Humans occupy a wide variety of environments, each with somewhat different demands, yet certain social and cultural traits seem to be nearly universal. This evidence, along with data from studies of identical twins, suggests that our genetic inheritance may influence some of our behaviors.

Group living confers certain advantages. Cooperation in defense against competitors, and against predators in earlier times, is an important function of the group, along with cooperation in obtaining food. Division of labor allows specialization and increased efficiency. Social facilitation — the stimulation of an activity or the improvement of performance due to the presence of others — and observational learning are also enhanced by group living. On the other hand, diseases spread more readily when individuals are grouped, and depletion of resources and contamination of the environment can be problems. Nevertheless, the advantages of group living apparently outweigh the disadvantages.

Humans have become dependent upon living in groups. Therefore it is necessary for the individual to be accepted and approved by the group, which requires a great deal of conformity to group standards. The requirement of conformity may stifle innovation.

Group living also involves some degree of crowding, and excessive crowding can be detrimental. Density crowding is a physical condition, while psychological crowding is a state of mind. Density crowding may or may not result in psychological crowding, depending upon the circumstances.

Humans, like most animals, maintain a certain "personal distance" from each other. Personal space is the invisible boundary around an individual that others should not enter, except in intimate circumstances.

Culture may be defined as the traditional modes of behaving and thinking that are passed from generation to generation by social learning. Cultures change due to dissatisfaction, innovation, and, perhaps most important, population pressures. Cultural selection involves the retaining of cultural practices and behaviors that are advantageous. Cultural evolution involves the adoption of new or modified practices that appear to be more beneficial. Cultural evolution can be influenced by genetic evolution, and vice versa, but cultural evolution can also proceed independently, and thus allows for rapid change.

The supplement to this chapter explores habitat selection in animals and humans.

In this chapter we explore human social behavior and culture from an evolutionary perspective. The evolutionary hypothesis holds that these phenomena are rooted in our biological inheritance, but not determined or predetermined by it. Human biology, social behavior, and culture are, of course, extremely complex and intertwined. As Barash (1982) says, "Our behavior is never an exclusive product of either biology or culture, acting alone, although in certain cases, one component or the other may predominate" (p. 150). Therefore it is very difficult, and in some cases impossible, to disentangle biological and cultural influences. It follows that any arguments for or against a biological basis for human social behavior and culture are always open to debate.

Nevertheless, there is a great deal of evidence that is consistent with the evolutionary hypothesis as it applies to human social behavior and culture. This evidence includes observations of behavior that are common to a variety of animal species and many diverse cultures, and striking similarities in the social behavior of identical twins. In addition, there are many aspects of social organization and cultural practices that may have emerged, and changed, because they contributed to the reproductive success of our ancestors.

Arguments and evidence related to the biological origins of social behavior and culture have, until recently, been ignored or downplayed in psychology as well as in other social sciences (Alland, 1973). However, with the appearance of E. O. Wilson's book *Sociobiology: The New Synthesis* (1975), things changed. Wilson and other biologists and anthropologists argue that human social behavior and culture cannot be divorced from our biological inheritance (Barash, 1977, 1982; Dawkins, 1976; Wilson, 1975, 1978). They do not deny that the cultural environment, through learning, is responsible for producing great diversity (and stability) in human social behavior. However, the sociobiologists and others (for example, Campbell, 1975, a psychologist) hold that certain social behaviors, and perhaps cultural traditions, may have roots in our evolutionary past. In other words, genes underlying the inclination to perform or learn certain behaviors and customs may have been preserved (selected) because they conferred advantages for survival and reproduction—that is, because they improved fitness.

Behavioral Similarities

Humans occupy virtually all types of environments on earth. Yet despite the wide variation in ecological conditions, certain social behaviors and cultural traits seem to be universal or nearly so. This, along with other lines of evidence, suggests that many of our social behaviors and customs may be rooted in our genetic inheritance.

Similarities with Animals

Humans have a number of social characteristics in common with other animals. Courtship, pair formation, parental care, and communication by gestures, including greeting gestures, all occur in a wide variety of animal species and are undeniably social behaviors. We also have numerous social characteristics in common with other anthropoids: the formation of social groups, intimate social groupings of ten to a hundred (rather than the two that occur in most species), the close relationship of age and power, social training of offspring during a long period of dependence, and social play as an important part of development during which the environment is explored, roles are practiced, and aggression is experimented with in a playful way. Play is also highly developed in other mammals, especially in species of cats and dogs, both wild and domestic.

The way mother chimpanzees attend their young is similar to mothering behavior in other higher primates.

Cultural Similarities among Humans

The social characteristics we share with other animals are impressive. But the characteristics we share with other humans, even people living in diverse cultures, form an almost endless list. It is true that cultural *variation* is the thing that is most apparent when we examine the dress and customs of people who live in other parts of the world. However, many of the variations among cultures seem to be differences in form, not in substance. For example, there are many different languages—cultural differences. However, all human groups have some form of language—a cultural universal.

If different cultural groups lived close to one another or even in quite similar environments it would seem logical to attribute cultural universals entirely to these factors. But what makes language and certain other cultural universals really impressive is that so many similarities exist among groups that are widely separated geographically and occupy very diverse environments. Although there is no direct evidence that any aspect of culture is inherited, an anthropologist notes that we

> must not overlook the fact that certain behavioral systems are more compatible with the total physiological and psychological structure of the human organism. It is probably for this reason, among others, that similarities between rather complex systems of behavior appear in widely scattered areas where there is little possibility that these similarities arose as a result of borrowing. The cultural traits which develop, develop against the background of biologically determined human nature (Alland, 1973, p. 236).

Murdock (1945, cited in Wilson, 1978) listed a number of characteristics that have been found in every culture known in history or ethnography:

> Age-grading, athletic sports, bodily adornment, calendar, cleanliness training, community organization, cooking, cooperative labor, cosmology, courtship, dancing, decorative art, divination, division of labor, dream interpretation, education, eschatology [religious or mythological concern with the ultimate destiny and purpose of humans], ethics, ethnobotany, etiquette, faith healing, family feasting, fire making, folklore, food taboos, funeral rites, games, gestures, gift-giving, government, greetings, hair styles, hospitality, housing, hygiene, incest taboos, inheritance rules, joking, kin groups, kinship nomenclature, language, law, luck, superstitions, magic, marriage, mealtimes, medicine, obstetrics, penal sanctions, personal names, population policy, postnatal care, pregnancy usages, property rights, propitiation of supernatural beings, puberty customs, religious ritual, residence rules, sexual restrictions, soul concepts, status differentiation, surgery, tool making, trade visiting, weaving, and weather control [p. 22].

In most cultures females find many ways to adorn themselves.

It is now thought that a few societies may permit incest, and there may be other exceptions to Murdock's "universals." Nevertheless, it is an impressive list, and an alert student may have noticed the absence of several items that we tend to assume are typical of humans. We would guess that other universals might include sharing, music, planning, love, jealousy, story telling, rules for settling disputes without bloodshed, adultery, helping, celebrations, and prejudice. No doubt you can think of others.

It is possible that all the characteristics of human societies mentioned above developed randomly and that some were passed between different groups. But it seems likely that a list of some eighty characteristics—and this excludes our "guess" list—that are typical of *all* human social organization might include several that have some basis in our genetic heritage. We are not saying there is a gene responsible for making humans want to adorn themselves, another urging us to invent courtship rituals, and still another compelling us to form a division of labor between males and females. The evolutionary hypothesis only suggests that human nature has something to do with some of the cultural universals we have been discussing. Cultural behaviors are not entirely random occurrences. They reflect in part the biological heritage of humans.

Studies of Twins

Another line of evidence that suggests our genes may influence social behavior — the study of identical twins — is perhaps more striking than the coincidence of cultural characteristics. The interesting aspect of these studies is how similar or different identical twins are in behavior and preferences.

There are many anecdotal as well as scientific reports indicating surprisingly strong similarities between identical twins separated from each other early in life. The resemblances involve social behaviors such as altruism and aggression, as well as various attributes of personality (Holden, 1980; Rushton, 1984). Such similarities suggest genetic influence because the twins are genetically identical but grew up in different environments.

In 1980 the media reported on triplets who had been separated at birth and adopted; none of them knew the others existed. When one of the triplets, Robert, went off to college, several students "recognized" him but called him Eddy. Robert learned that Eddy had attended that school the year before, and that he and Eddy not only looked alike but had the same birth date. He located Eddy, and they concluded they were identical twins. Newspapers ran the story and their pictures, and then Eddy's mother got a phone call from David, who suggested that he, Robert, and Eddy were triplets. All this came as a complete surprise to the adoptive parents also, for none of them had been told their son had brothers.

Robert, Eddy, and David are not only nearly identical in appearance. All three are extroverts who often use their hands to express themselves, and wiggle their tongues to accentuate a grin. Their speech and laughter are alike, they smoke, heavily, the same cigarettes (hard-pack Marlboros) and hold them the same way, and they have similar tastes in food, sports, women, and music.

Similar examples appear from time to time, but it is difficult to find for study identical twins (or triplets) who were separated at birth and had no contact until they are studied. Often when children are separated they are placed with relatives, and are not only aware of each other's existence but also see each other at family gatherings. Another problem, perhaps the most important one, is that many twins who are studied are chosen for study *because* they are similar, while dissimilar pairs are disqualified. Still another problem in research is that adoption agencies often place children with families that are socially and economically similar to the natural parents, so that the home environments of the separated siblings are often similar to each other. However, in the case of Robert, Eddy, and David, several of the characteristics they have in common seem to have little to do with their home lives. The probability of so many strikingly similar characteristics being due to similarities in the environments of the separated triplets must be extremely small.

Susan Farber (1981) reviewed studies of 121 pairs of separated identical twins, all that had been published in the world literature at the time except Cyril Burt's "findings," which are thought by many to have been falsified. Of the 121 cases Farber reviewed, only three fit the ideal, having been separated during the first year of life and unaware they had a twin until they were studied. However, a large number of the cases showed coincidence of personality and tastes similar to the triplets.

The most interesting aspect of Farber's findings is that twins who had the least contact, particularly during the first ten years of their lives, were most similar in personality, while those with most contact were least similar. Those with much contact *could* have been dissimilar due to competition or the way they were treated — we don't know. The striking result is the similarity of those with least contact, which may be due to their genetic identity. However, we must be cautious about this interpretation. Currently there is little known about the probability of finding strong similarities in social characteristics in pairs of individuals who are *not* identical twins.

Social Organization and Fitness

Social Grouping

In most species of animals, social behavior for adults consists mainly of mating. In relatively few species the mother has the additional social behavior of caring for the young, but only until they are self-sufficient. In still fewer the father stays and helps.

At the other extreme are the long-term social groups formed by a few species such as lions, wolves, and several species of anthropoids, with the ultimate in society being found in humans. A society emerges when several individuals join together to form a larger group. Why do some animals live in groups? Or, put more precisely, what functions do groups serve that make group living advantageous?

Fitness, or biological success, consists of survival and the production of *successful* offspring. Anyone who failed to meet these requirements made no genetic contribution to the generations that followed, and they are not our ancestors. Compared with solitary existence, group living apparently conferred advantage on its members in terms of survival and reproduction. And if this is so, selection would be strong for individuals who live socially, and in social harmony.

Bear in mind that people who live in isolation, such as trappers in the Canadian northland today, are faced with special problems of survival, but they are not independent of "the group." They are dependent upon others to supply many items, including traps, guns, cartridges, tools, and some food. An interesting view of the difficulties of wilderness survival and dependence on the outside world in present-day Alaska can be found in *Coming into the Country* by John McPhee.

Apparently the optimal size for prehistoric and modern aboriginal groups, mainly hunter-gatherers, is about twenty to sixty people (Eckhardt, 1979). These groups are subdivisions of larger groups of a few hundred that share a common language and culture, and exchange members from time to time, especially females. While groups must be small enough to avoid depleting resources too rapidly, they also must be able to defend these resources. Groups should be large enough to defend against predators or human enemies, both by detecting them and repelling them.

Modern aborigines, father and son. Apparently the optimal size for aboriginal groups is between twenty and sixty individuals, although they are usually subdivisions of larger groups.

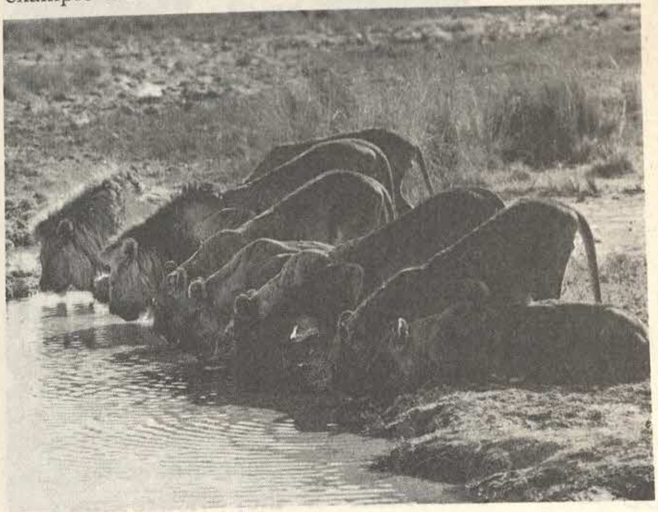
Anyone who has carefully observed feeding birds will have noticed that solitary individuals often spend as much or more time with their heads up looking around as they do feeding. However, while feeding in flocks, any one individual looks up only occasionally, depending partly on others to give warnings of danger. Thus groups can capitalize on the eyes or ears or noses of several individuals and are less likely to be surprised, waste fewer calories in encounters with predators, and are able to obtain more calories per unit of feeding time. Detecting, avoiding, and repelling predators may have been primary reasons for group living in our ancestors.

Human groups can also cooperate in obtaining food. Cooperation is useful not only in killing big game animals, but in flushing out small game. In addition, several searching individuals are more likely to locate a source of vegetable food than are single individuals.

Another sizable advantage of group living is the opportunity for division of labor. This occurs between men and women and it also occurs within each sex. Suppose you broke your leg and it didn't heal properly, so you can't participate in the hunt. However, you are good at making tools such as arrows and I am not, or maybe I'd rather do something else. You supply me with implements and I'll supply you with meat. Different but complementary roles are an important aspect of the development of culture.

Social facilitation is another group function. The presence of others often improves performance, and in many species individuals in groups often do more of something and/or do it more readily or longer than solitary individuals. Observing someone else do something often stimulates similar behavior in the

If one lion starts to drink, then others might join in—an example of social facilitation.



observer, which in turn can serve as feedback to maintain the behavior in the other (see Chapter 8). An interesting but puzzling example of social facilitation is the development of simultaneous menstrual cycles in women living together (McClintock, 1971). Evidence to date indicates that odor cues associated with perspiration play a role in influencing this synchrony (Goldstein, 1984).

Of course, compared with solitary or single-family existence, groups also provide greatly expanded potential for observational learning; for the transmission of beneficial traditions and improvisations; and for social play, which appears to be important in development.

There are also disadvantages to living in groups. Diseases are more readily transmitted, environmental contamination is more likely, and resource depletion may require locating a new habitat from time to time. However, for humans the advantages of group living apparently outweigh disadvantages. Otherwise, according to ecological and evolutionary theories, living in isolation or only with the immediate family should be much more common, predominant, or even universal.

Dependency, Conformity, and Innovation

Because humans are dependent upon living in groups, it is necessary for individuals to be accepted and approved by the group and avoid being driven out. Certain behaviors are rewarded, others are not, and still others are punished. Standards are set by the development of rules. Individuals are expected to obey these rules at least most of the time, and some rules all the time. Thus conformity is rewarded, and people often feel uncomfortable if they violate rules—cheating, stealing, not returning a favor, or hanging back and letting others do more than their share of work. Of course rules may vary with culture.

The tendency to conform makes it difficult to innovate. Innovation that does not disturb the status quo, or does not disturb it too much, is often rewarded, at least by social approval. More drastic suggestions for change are commonly criticized or rejected; sometimes the innovator is persecuted. A famous example is Galileo, who was arrested and brought before the Inquisition for suggesting that the earth was not the center of the universe.

Social psychologists have accumulated a sizable research literature on the topic of conformity. Freedman, Sears, and Carlsmith (1981) characterize conformity as doing something because others are doing it, and consider conformity to be a special type of compliance or obedience: "When people do what they are asked—even though they would prefer not to—we call it *compliance* or *obedience*" (p. 312).

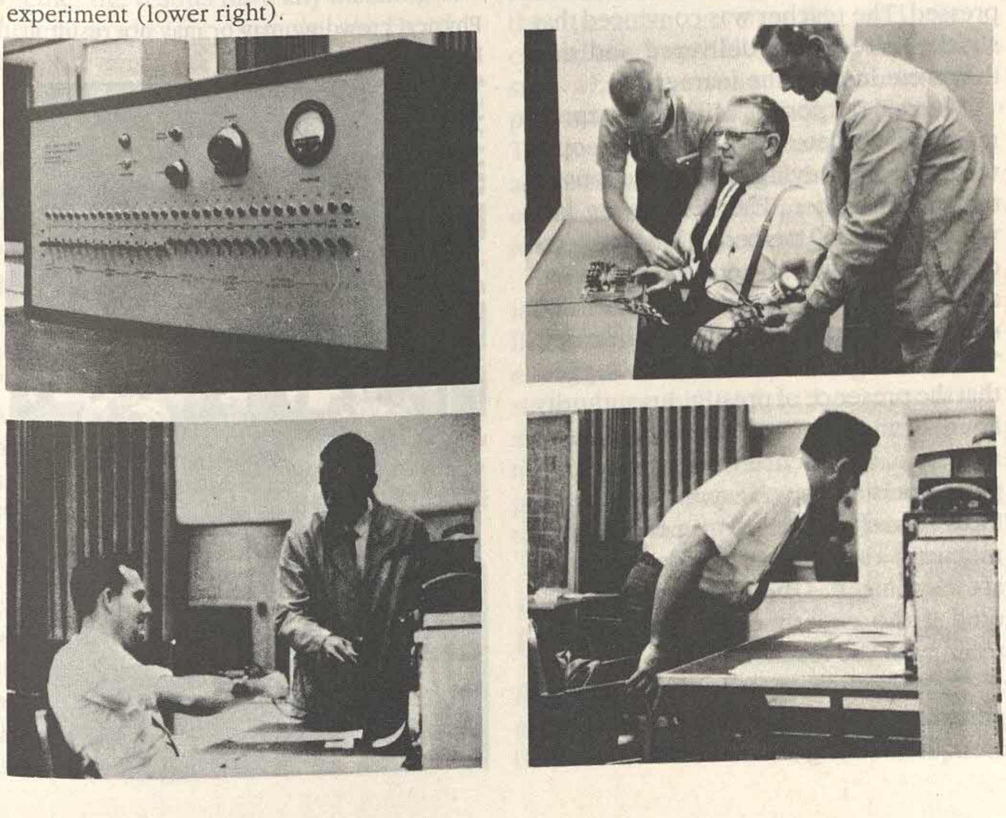
A classic study of conformity was conducted by Solomon Asch (1951). The experimenter asked five college students to make judgments of relative line lengths. The subjects were seated around a table and shown a white card displaying three black parallel lines of distinctly different lengths. Then a second card with only one line was shown. The subjects were asked to pick the line on the first card that was the same length as the line on the second card, an easy task.

Subjects took turns, according to seating order, giving their answers verbally. On the third trial of the experiment the first subject to respond made an obvious incorrect choice, which was repeated by the second, third, and fourth subjects.

Unbeknown to the fifth subject, the first four were confederates of the experimenter; they were purposely making the same incorrect choice. In many repetitions of the experiment, "fifth" subjects made the same incorrect response as the first four, even though they knew it to be wrong and were distressed about it. This simple experiment, and many variations of it, show that people have a strong tendency to do what others are doing, even though they see no logical reason for doing so.

A more dramatic experiment dealt with obedience, and its findings continue to cause disbelief and distress in many who learn about them. The study was conducted by Stanley Milgram (1963) and, like Asch's experiment, it involved deception on the part of the experimenter. Subjects were people answering a newspaper ad asking for volunteers for a psychological study.

Upon arriving at the laboratory, subjects were told they would be involved in a study of the effects of punishment on learning. Subjects were paired, and the experimenter designated one to be the learner and the other the teacher, a random designation—or so it appeared to the one designated the teacher. The teacher was seated at an ominous-looking apparatus and told that it was de-



The ominous-looking apparatus in the upper-left photo is the shock generator used in Stanley Milgram's experiments on obedience. The remaining photos show the learner being strapped into the apparatus (upper right), the teacher receiving instructions from the experimenter (lower left), and, later, attempting to terminate the experiment (lower right).

signed to deliver electric shocks of varying intensity. The learner was seated in a separate room, unseen by the teacher. The experimenter instructed the teacher to read a list of word pairs through a microphone for the learner to memorize, while the experimenter observed. If the learner responded incorrectly, the teacher was to press a lever that would deliver an electric shock to the learner. The "shock machine" was equipped with levers with labels that varied from 15 to 450 volts. For each incorrect response, or absence of a response, the teacher was to increase the level of shock until the maximum, 450 volts, was reached.

What the teacher didn't know was that the learner was a confederate of the experimenter and that no shocks were actually delivered, even though the learner protested violently when the levers were pressed. The teacher was convinced that shocks were being delivered and that they were hurting the learner.

The real purpose of Milgram's experiment was to determine how far people would go in obeying the instructions of the experimenter. The disquieting fact was that over 60 percent of the subjects continued to administer "shocks" up to and including the maximum intensity, despite the protests of the learners. These and other similar results suggest that the presence of prestigious authority figures can be an extremely persuasive influence. Obedience in this type of experiment is not as widespread if prestige factors, such as identifying the experimenter as a scientist at a major university, are eliminated. Obedience is also lowered if the experimenter is not in the room with the teacher.

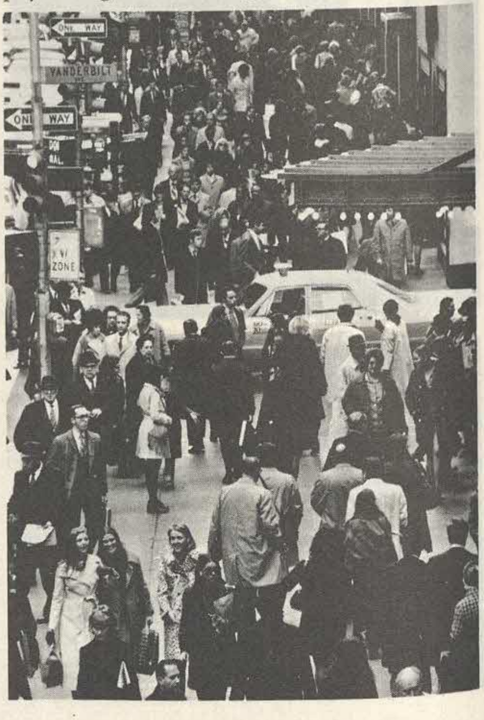
These and many other findings suggest that tendencies to conform and obey are quite strong under certain conditions. Of course, the findings come from artificial laboratory experiments, and it is difficult to know whether they reflect the true state of affairs in normal social settings. Nevertheless, the results are provocative.

Crowding

Compared with solitary living, group living apparently increases individual fitness. But it is possible to have too much of a good thing. There is evidence that increases in the density of a social group —crowding—cannot go unchecked without disturbing consequences.

Several experiments with animals, often with rats, have demonstrated detrimental effects of crowding (Calhoun, 1962; Christian, Flyger, & Davis, 1960).

Physical crowding may or may not result in psychological crowding.



At the beginning of the experiments the animals had plenty of space and ample food and water. With time, numbers increased, and as crowding grew worse, aggression increased. Disorientation occurred and nest building was disturbed, incomplete, or ceased. Cannibalism occurred, especially of the young, and sexual activity declined. In many studies of animal crowding the adrenal cortex was examined and found to be enlarged, suggesting that the animals had been under stress (Riley, Spackman, & Fitzmaurice, 1981; Selye, 1936).

What does this mean for humans? We don't know. Reports of experimentation on human subjects are mixed. Generally, those that showed no adverse effect of crowding on humans were done under laboratory conditions so artificial and contrived as to bring into question whether the results have any meaning in the real world (for example, see Freedman, Klevansky, & Ehrlich, 1971).

A study carried out in an actual living situation, and supported by additional laboratory work, showed definite negative effects of crowding. Baum and Valins (1977) studied students living in "crowded" dormitories with long corridors, where thirty-two to forty people shared hallway, lounge, and bathrooms, and compared them with students in "uncrowded" dorms with short hallways, in which only six to twenty shared public areas. All students were randomly assigned to rooms, and the number of students per room was the same for the "crowded" and "uncrowded" dorms.

In the "crowded" dorm students encountered each other more often and less predictably; they reported this to be stressful, and tended to withdraw from interaction with neighbors. In addition, they were less motivated and had more trouble making decisions than students living in the "uncrowded" dorm. Follow-up studies showed that the withdrawal and passiveness increased with time.

Density crowding is a physical condition. Psychological crowding is a state of mind. It is possible for people to sit closely packed in a movie theater or sports arena and not *feel* crowded, even though the number of square feet per person is small. However, in these high-density situations they are spectators, and interacting very little with those seated near them. In addition, they are in the high-density situation by choice, and they know it will persist only for a short time. In such cases density crowding does not necessarily result in psychological crowding.

However, some degree of density is necessary for a person to feel crowded. Schmidt and Keating (1979) analyzed the literature on crowding and concluded that psychological crowding results when a person attributes a loss of personal control to a density situation. This loss of control may take the form of actual blocking of goals, interruption of or interference with a particular behavior, or cognitive overload.

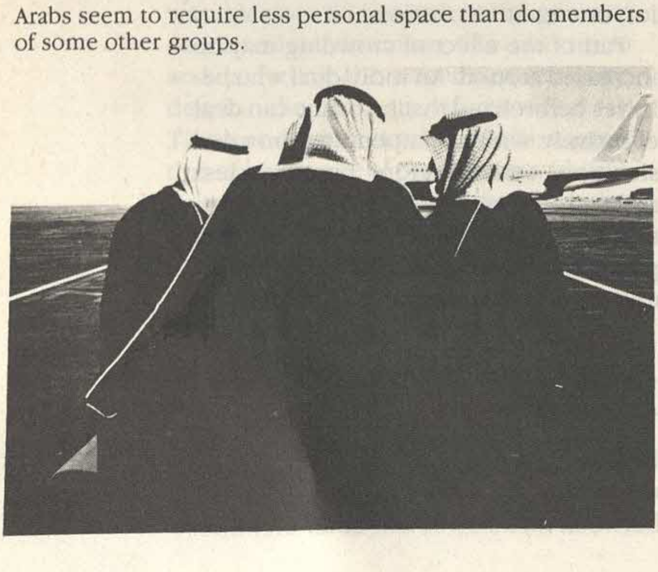
Part of the effect of crowding may be increased arousal. An individual who believes beforehand that he or she can deal effectively with an impending crowded situation, and therefore becomes less aroused and less stressed when the situation occurs, is less likely to feel a loss of personal control and therefore less likely to perceive psychological crowding.

Interpersonal Distance or Personal Space

In many species of animals, individuals maintain a certain "personal distance" between themselves and other members of the same species. For example, if you watch wildlife films on TV you will notice that herd animals such as zebras or wildebeests are often rather regularly spaced from each other. Many species observe a *flight distance*: when something comes closer than that distance the animal will flee. Flight distance may vary according to previous experience and environmental conditions. Some species of jaybirds are often known as "camp robbers" because they will come within a few feet of people in a campground to grab a bit of food, while the members of the same species in other areas have a much greater flight distance. Some animals also observe a *fight distance.* Even though they might ordinarily flee, some animals will attack if approached too closely, particularly if escape is blocked (Denny, 1980).

Humans also observe interpersonal distances. Hall (1960) defined four zones of interpersonal activity: intimate, from contact to eighteen inches; personal distance, eighteen inches to four feet; social distance, four to twelve feet, and public distance, twelve to twenty-five feet. The term **personal space** has been used for some years to define the invisible boundary around an individual that others should not normally enter. This varies in accordance with the social situation, perhaps in the four ways outlined by Hall, and with the culture. Thus we tend to keep a bubble of space around us in all but intimate situations, and intimate situations can be thought of as violating personal space. Vision, eye contact, and hearing operate most effectively at moderate distances, and therefore communication is facilitated at these distances.

Arabs seem to require less personal space than do members of some other groups.



Culture

> Modern man can be said to have been launched by a two-stage acceleration in mental evolution. The first occurred during the transition from a large arboreal primate to the first man-apes *(Australopithecus)* . . . and may have required as much as ten million years. . . . The evolution of those intermediate hominids was marked by an accelerating increase in brain capacity. Simultaneously,* erect posture and a striding, bipedal locomotion were perfected, and the hands were molded to acquire the precision grip. These early men undoubtedly used tools to a much greater extent than do modern chimpanzees. . . .
>
> The second, much more rapid phase of acceleration began about 100,000 years ago. It consisted primarily of cultural evolution and must have been phenotypic in nature, building upon the genetic potential in the brain that had

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*The simultaneous appearance of a larger brain, upright posture, and precision in the hand grip was assumed by virtually all scientists until the discovery of "Lucy" and *Australopithecus afarensis* (see Chapter 4).

> accumulated over the previous millions of years. The brain had reached a threshold, and a wholly new, enormously more rapid form of mental evolution took over. This second phase was in no sense planned, and its potential is only now being revealed (Wilson, 1975, pp. 565–66).

Culture can be defined as traditional modes of behaving and thinking that are passed from one generation to another by social learning. The universals in human culture mentioned earlier in this chapter are the sorts of things we want to consider first, although only briefly. However, it is not the items themselves we want to consider, but rather the idea that there *are* cultural universals. Certainly there are differences among cultures in the *way* the universals are expressed, but that is not important here. Once we get beneath this veneer, the consistency of social relationships is striking.

As with other widespread animal species, many differences appear geographically among human groups. Courtship rituals vary greatly among cultures, but they are still courtship rituals. Like different languages, different courtship rituals accomplish the same goal; only the "sound" varies. Many other cultural differences are like this also. In other words, humans have the genetic foundations for various types of behavior, but how these will develop depends on the environment, both social and ecological. Humans are "wired" with marvelous flexibility, but we are wired in certain ways.

Human behavior is flexible and can develop in a variety of ways.

We hope it is clear that we are not talking about instincts. One of the great advantages humans have over other animals is that physically we are generalists. Most notably, our hands are not specialized for digging or for climbing (no claws) and thus are left free of specialized structure so that we are more flexible and may employ our hands in a great variety of tasks. We do, however, retain the genetic program that shapes our hands as distinctively human. Another great advantage we have over other animals is that we are not loaded down with instincts, so that our behaviors are more flexible and can develop in a variety of ways. But we retain our particular genetic predispositions—our "wiring"—to develop language, to behave sexually, to behave socially.

Cultural Change

The second point to be made regarding culture is that cultures change. Substantial and unusually rapid cultural change occurred during the 1960s and '70s. This stemmed at least partly from the counterculture, the so-called hippie movement, which was itself at least partly an outgrowth of the United States involvement in Vietnam. For the first time in United States history there was widespread resistance to conscription for military service. The questioning of old values was expressed most visibly by long hair and very casual dress. *Ecology* became a household word; student dress codes were dropped; small cars became increasingly popular, well before the oil "shortage"; unmarried couples started living together, openly. Women entered the work force in unprecedented numbers, and the women's liberation movement became a prominent social phenomenon. Drugs emerged from the underground, people experimented with hallucinogens, and marijuana became an integral part of youth culture, with "joints" smoked openly at parties. Sex became an acceptable word in conversation, and sex and abortion were talked about openly, even on television.

These are only a few of the external and visible changes that occurred in the 1960s and '70s. Many more have occurred since. The point is that cultural changes aren't necessarily things that happened a long time ago; they are a continuous and integral part of our world. However, the changes we will now discuss are much greater and occurred over far longer time spans.

We know that humans added tool making to their culture at least three million years ago. Very similar tools were being made tens of thousands of years later, but tools of advanced design and made of better materials (that is, different rocks) were added. This indicates an evolving cultural tradition, and suggests an increasingly sophisticated nervous system.

The great advances in the sophistication of stone tools paralleled the rapid increase in size of the human brain. This appears to be an example of mutual stimulation and reinforcement between behavioral-cultural evolution and biological evolution. The value of improving tools for more efficient harvesting of animal and plant food, along with the value of cooperation in killing large animals and living in groups, may have placed a premium on both cognitive and communicative abilities. Under these conditions, an even larger and more sophisticated brain would have high and immediate survival value. Thus cultural innovation made possible by biological evolution could have been an important selective pressure promoting *further* biological evolution, which in turn could lead to even more cultural diversity.

Had it not been for population increase humans might have remained in small bands, spending only a few hours a day "making a living" by hunting and gathering, as some aborigines still do today. Why bother with agriculture when needs can be fulfilled with a few hours of hunting and collecting?

But populations did expand, and that meant that more resources were required. As long as there were areas unoccupied by humans it was possible for a group to split if it became too large for local resources to support or the group could move to a new, unused area. In this way humans spread over the face of the earth.

The following is a hypothetical, computer-assisted scenario of what might have occurred after the immigration of people across the Bering Land Bridge some 15,000 to 40,000 years ago. It shows how reproduction in a small group of hunter-gatherers could lead to a population expansion covering thousands of miles in less than three hundred years, and demonstrates the tremendous impact on food resources that could result from this hypothetical population explosion.

> We introduce 100 Paleoindians at Edmonton [in Alberta, Canada]. The hunters take an average of 13 animal units per person per year. One person in a family of four does most of the killing, at an average rate of one animal unit per week. . . . The hunting is easy; the [band] doubles every 20 years until local herds are depleted and fresh territory must be found. In 120 years the Edmonton population grows to 5,409. It is concentrated on a front 59 miles deep at a density of 0.37 persons per square mile. Behind the front, the megafauna is exterminated. By 220 years, the front reaches northern Colorado. . . . in 73 years, the front advances the remaining 1,000 miles [to the Gulf of Mexico], attains a depth of 76 miles, and reaches a maximum of just over 100,000 people. The front does not advance more than 20 miles in one year. In 293 years the hunters destroy the megafauna of 93 million animal units (Mosimann & Martin, 1975, p. 308).

Marvin Harris quoted this study in his 1977 *Cannibals and Kings: The Origins of Cultures,* from which much of the following discussion is drawn. The scenario is perhaps an oversimplified model of human population expansion, but it is a reasonable account of how rapidly a population might grow. In the process of migrating and hunting, a continually expanding population could destroy a large portion of its normal food supply and be forced to turn to alternative sources, in this case small animals and a greater utilization of plants. The early history of parts of Middle America illustrates how this process of intensification occurred.

Pyramids near Mexico City, D.F.

MacNeish (1972) studied the process of intensification in the Tehuacán Valley of Mexico. According to MacNeish, between 9000 and 7000 B.P. (before the present) horses and antelope were hunted to extinction, and hunters turned to jackrabbits and giant turtles until these also were extinct. Early in this period an average of more than 80 percent of the people's caloric intake consisted of meat. By about 4000 B.P. this had dropped to about 47 percent during the maximum hunting season and 15 percent in the minimum season. By about 2800 B.P. permanently inhabited villages based on agriculture were established, the percentage of meat had dropped still more, and seasonal differences in meat supply had disappeared. As species were killed off and the meat supply declined, the hunters used increasingly efficient weapons—lances, spear throwers, darts, and finally bows and arrows—which probably helped sustain levels of harvest temporarily, but accelerated the ultimate decline in availability. The use of *cultivated* plants is estimated to have increased during the period covered from less than 1 percent to about 42 percent of caloric intake by about 1800 B.P.; of course, wild plants were used too.

Agriculture is an efficient way to produce calories. Rudimentary gardening produces about ten calories for each calorie expended on production or a ratio of 10 : 1. Agriculture's ratio is about 30 : 1, and irrigated agriculture's about 50 : 1. In the absence of big game, hunting never even reached 10 : 1. However, during the past nine thousand years nutrition has steadily deteriorated in the Tehuacán Valley. Why? Because the population kept increasing.

We turn now to the Teotihuacán Valley, a branch of the Valley of Mexico. Permanent villages were established there at around the same time as in the Tehuacán Valley. By 2000 B.P. the city of Teotihuacán contained about four thousand people. Forest land was cleared over a wide area to provide wood for fuel, house beams, and the manufacture of lime plaster. This deforestation probably altered the pattern of rainfall and surface runoff. Between 1800 and 1300 B.P., when the city of Teotihuacán had grown to 125,000, various means of increasing agricultural production had been instituted. First slash-and-burn farming was intensified, but soon population pressure made shorter crop rotation periods necessary and production declined. Then irrigation was introduced, using spring-fed canals, and eventually 14,000 acres were under irrigation and could grow two crops per year. But around 1300 B.P. the city of Teotihuacán collapsed, possibly due to a drop in the availability of water, which in turn may have been partly caused by earlier deforestation.

Not far away, on the edges of Lake Texcoco, the Aztecs became dominant. To the farming technology already mentioned, the Aztecs added ridged mounds extending out into the lake, which required even more labor and energy than building canals. Still the population grew in the Valley of Mexico—from a few tens of thousands around 1800 B.P. to about two million in 800 B.P. The steady growth of population, which continues over the world today and causes at least two-thirds of its inhabitants to go to bed hungry, eliminated meat from the diet of the common people. Corn and beans together provide the same essential amino acids that meat does, but they are not as satisfactory a source because they are bulkier and harder to digest. They also have less fat. But the biggest problem was that there simply was not enough of them. It was often necessary for the people to skim algae from the surface of Lake Texcoco for use as food.

The only domesticated animals in early Middle America were dogs and turkeys. (North American Indians also kept dogs, and ate them as needed.) But dogs are a costly source of protein because they feed mostly on meat, which is better fed to people. Turkeys eat mostly grain, and it is more economical to feed the grain to humans. It is a well-known ecological principle that the energy lost at each step in a food chain is something like 90 percent. Therefore dogs or turkeys provided only about 10 percent of the calories that would have been available to humans if they had eaten the food these animals consumed.

Food Shortages and Cultural Practices

When Cortez arrived in Mexico in 1549 the Aztecs were practicing human sacrifice on a massive scale in religious ceremonies. It has been suggested that this was a means of population control (Cook, 1946), and of course it would have some effect. However, almost all the victims were males. As we shall see when we discuss human sexual behavior in Chapter 17, and as you can probably imagine anyway, limitation on reproduction is determined by the number of women, not the number of men. Surely this must have been apparent to the Aztecs also.

Apparently most of the victims sacrificed were prisoners taken in battle. Each had an owner, and was housed in the owner's compound until the day of sacrifice. On that day the prisoner was taken to the top of a pyramid, where priests removed his heart and burned it as an offering to the gods. The body was then thrown down the side of the pyramid and delivered to its owner. It was then cut up for cooking and a feast was held.

Harris speculates that human sacrifice by the Aztecs was a means of supplying some meat to a protein-hungry populace:

> All edible parts were used in a manner strictly comparable to the consumption of the flesh of domesticated animals. The Aztec priests can legitimately be described as ritual slaughterers in a state-sponsored system geared to the production and redistribution of substantial amounts of animal protein in the form of human flesh (p. 109).

Human sacrifice and the eating of human flesh were not limited to the Aztecs or other Middle American cultures. Some North American Indians also indulged in these practices, but usually on a small scale. And Harris tells us:

> As recently as fifty or a hundred years ago, small-scale sacrifice of prisoners of war and the redistribution of their flesh were common practices in hundreds of pre-state societies scattered across Africa south of the Sahara, Southeast Asia, Malaysia, Indonesia, and Oceania (p. 113).

In fact, it appears that the brains had been removed from many of the skulls of *Homo erectus* found in China and dated at about 350,000 B.P. (Chapter 4); since the brains were removed, most people assume they were eaten. The eating of parts of a vanquished adversary has been known to occur among many aborigines. It is often associated with the idea that the consumer will thereby gain some of the powers of the deceased, and this idea has been especially associated with eating the brains.

Conditions in the Middle East were quite different from those in Mexico. Hunter-gatherers there built villages where they could harvest wild stands of grain from grasses such as wild wheat and barley. Wild peas and lentils are also native to the area, as were the ancestors of domestic cattle, goats, pigs, and sheep. Stands of wild wheat are so dense in some areas today that a family can gather enough grain for the year in about three weeks, using a flint sickle—about two pounds of grain per man hour. Because of this abundance, permanent villages appeared in the Middle East as early as 14,000 B.P., around 11,000 years earlier than in Middle America. Big game had become extinct there too, but because the hunter-gatherers built villages in the middle of natural grain fields, meat literally came to them. Wild sheep and goats came to eat grain and could be "hunted" easily. At some time or other these animals must have posed a threat to the grain before harvest. This would have been a natural time to start controlling their movements, and ultimately herding was developed. Goats and sheep thrive on grass and on stubble left after harvesting grain, and therefore can be raised on foods unsuitable for humans. Their ex-

A Ghoorka regiment performing ritual animal sacrifice.

crement also fertilizes the fields to some extent. They could be confined by fences, used to provide milk or wool, and killed for meat as needed.

Eventually populations in the Middle East grew to the point where people there also developed ritual sacrifices that distributed meat, but they were animal rather than human sacrifices. The biblical Book of Leviticus gives detailed instructions for animal sacrifice. As population overtook the meat supply in many places, a choice had to be made between raising domestic animals or food plants. The decision was in favor of food plants in places where they could be grown, a wise decision considering the energy loss in food chains. In addition, rules were imposed forbidding the Israelites to eat certain kinds of meat. Such rules may have been a response to the dwindling supply of meat in general, and the energy costs associated with raising certain kinds of domestic animals. For example, the prohibition in Leviticus against raising and eating pigs may be understandable in terms of the cost-effectiveness of this form of food production.

While one might guess that the prohibition was because eating pork can result in trichinosis, pigs ordinarily do not harbor *Trichinella* in hot climates. It is perhaps more likely that the costs associated with raising pigs for food had outstripped the benefits.

Consider that pigs are primarily dwellers in forests and wet areas, where they dig for roots and tubers and feed on fruits and nuts that fall to the ground. They also do well on grain, but do not do well in the hot, sunny places where grain grows best. Pigs can't sweat, so they need a ready supply of water for cooling, and they need shade. And even though pigs are 20 percent efficient in converting food to meat and fat, compared with 7 percent for cattle and 10 percent for fowl, they aren't useful for riding, milking, catching rodents, or carrying or hauling things; nor do they produce fiber for weaving. Nor are they pleasing aesthetically. Unless they can be raised in their natural habitat on their natural food, they can become too "expensive."

Consider also that beginning about 9000 B.P., millions of acres of Middle East forests were converted to farming and herding, and millions of acres of former herding and farming lands became useless, due to misuse. About 3200 B.P. the Israelites entered Palestine, occupying and destroying much of the hilly wooded area and changing it to irrigation farming. As agriculture expanded from the flatlands at the expense of forests, pigs would have become even more expensive to raise.

A similar cost-benefit situation arose in India after about 1400 B.P. Cattle became so expensive to raise that only the wealthy could afford to use them for food, but unlike pigs they were essential for other purposes. Every farmer needed at least a pair of oxen for cultivation and a cow to produce more oxen. However, these farmers could barely subsist, even without sacrificing grain to beef production. Moreover, Indian agriculture depended on monsoons, but there were years when the monsoons did not come. When this happened, how could the people refrain from eating cattle when they were hungry? The answer was a religious prohibition, much like that against raising and eating pork, but this one only against the eating. Thus Buddhism and Hinduism came to forbid the eating of cattle, a prohibition that the common people had already been forced to observe for a long time.

The aspects of culture we have dealt with here are mainly those associated with food traditions. The hunter-gatherers of the Middle East changed their culture and settled into permanent villages for the same reasons as those in Middle America; increased hunting due to population pressure had contributed to the depletion of game animals, and it became necessary to concentrate on plant food. However, ecological conditions in the two areas were quite different.

Due to natural fields of grain it was nutritionally profitable for people in the Middle East to establish permanent villages before food animals had been hunted to extinction. They continued their seed-gathering culture, eventually changing over to cultivation, while at the same time enjoying meat in their dishes. Ultimately, however, population increase reduced the per capita availability of meat to the point where it could be made available only at special times, when animal sacrifices were held and meat was distributed. This evolved into religious rituals, and then prohibitions.

In Middle America conditions were

In India, cattle are not eaten but often roam the streets starving.

quite different. Food plants did not grow in such concentrated abundance, and animals were hunted until all but small species were extinct. Cultivation was started while the people were still nomadic, following game from place to place, and the first permanent houses were used for only part of the year. Villages of permanent residences were not established until all else had failed, and then it was for the purpose of intensive agriculture rather than convenient seed-gathering. There was very little in the way of animal meat, and ultimately human sacrifice was ritualized, perhaps as a means of providing the people with at least a token amount of meat.

Culture and Evolution

In discussing culture, we have tried to show that different cultures have much in common, that cultures change, and that changes sometimes occur along common pathways. There is often good reason for change—the change from hunting to farming cultures we have discussed, for example. However, this does not mean that all cultural changes are adaptive responses to changing pressures for survival. Undoubtedly, many cultural changes have occurred primarily because of myth or superstition. Moreover, there is no guarantee that a particular cultural change will improve *everyone's,* or *anyone's,* fitness, regardless of the reasons for its adoption (Barkow, 1983).

Cultural selection involves the retention of cultural practices and behaviors that experience indicates are advantageous. Cultural evolution involves abandoning practices in favor of new or modified practices that appear to be more beneficial. However, people often hesitate to abandon the tried and true, and they also tend to conform to social norms. Both of these tendencies may retard cultural evolution. For example, the Middle Americans did not fully adopt agriculture until most of the animals they depended on for food were rare or extinct, about five thousand years after the extinction of horses and antelope. It is likely there were individuals arguing for a change to agriculture long before it came about, and had others listened to them perhaps meat would have remained a part of the regular diet, or at least have disappeared later.

Cultural evolution can be influenced by genetic evolution, and genetic evolution can be influenced by cultural evolution. But cultural evolution often proceeds independently, and allows much more rapid change than does genetic evolution. It is therefore a very powerful human characteristic which can have high survival value. Cultural selection and cultural evolution undoubtedly account for far more forms of human behavior than do natural selection and genetic evolution. But cultural selection and evolution are similar to natural selection and genetic evolution, in that cultures also respond to environmental pressures and undergo changes that may be adaptive. A new idea is to cultural evolution what a new mutation or recombination is to genetic evolution. If an idea is advantageous *and* becomes accepted, it may spread through the population and become the norm.

Supplement 1 Habitat Selection

Humans occupy, cope with, and perhaps even enjoy nearly every type of terrestrial environment that exists on earth. However, it seems clear that some types of environments are more attractive than are others. Residential real estate prices reflect the desirability of waterfront living, and of homes on hills or other high places where there is a view.

What is responsible for the origin of preferences for certain kinds of habitats? Gordon Orians, a well-known biologist, proposed (1980a) that human habitat preferences and selection may have a genetic-evolutionary basis. In this supplement we will examine habitat selection by animals, and offer speculations based on Orians's proposals, on habitat selection by humans.

Habitat Selection by Animals

It is apparent even to an inexperienced observer that particular species of animals occur naturally only in certain types of environments — certain habitats. Antelope are found in grasslands or in savannas, but not in forests. Tree squirrels and most primates are found in forests but not in grasslands or savannas. Why is this so?

The answer is not difficult to find. Certain species are found in particular habitat types because they can survive and reproduce there. Surviving and reproducing involve certain behaviors, and one of the problems all animals face is making decisions, consciously or unconsciously, regarding where to perform these behaviors. These decisions are what is involved in habitat selection — the choice of an appropriate place to live. Resources such as food and sites for producing young must be sufficient for at least one breeding season, competitors must not be too numerous, and hiding places or other means of avoiding predators must be available.

It is sometimes possible for animals simply to stay near the place where they grew up. More often, however, the particular habitat where they were born is already at carrying capacity, meaning that the reproducing individuals already living there are fully utilizing essential resources and there isn't room for any more members of the species. Fox squirrels force their youngsters to leave in the fall of the year they are born, and beavers do this the second year. Therefore it is often necessary for young animals to find another place to live. In addition, many animals migrate annually, from breeding habitats to overwintering areas, and back again the following spring. In both of these situations, animals must be able to recognize habitats that are suitable for their survival and reproduction. A good way to do this is to have some sort of memory for the characteristics of the habitat where one grew up. The fact that one's parents reproduced there is strong evidence that a similar habitat probably would be suitable, that one's adaptations would be more effective there than in other environments. In fact, many animals, including humans, do show a strong preference for the type of habitat where they grew up, and even for the particular place.

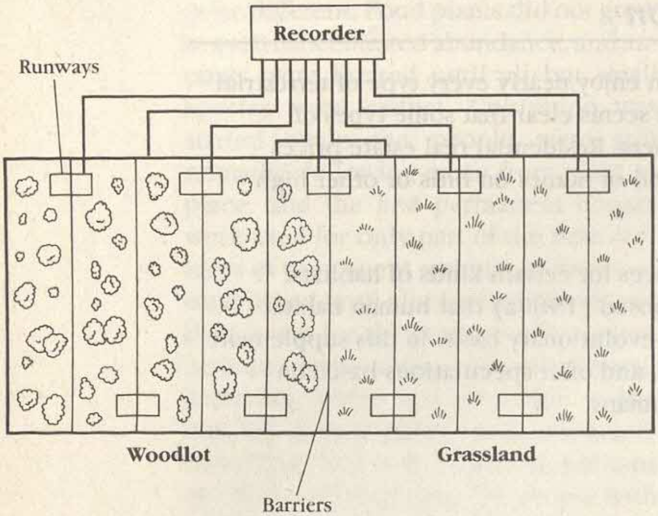


Figure 15.1 Enclosure used for experiments on habitat preferences of mice. Passage of mice from section to section is recorded as they pass through runways.

It is obvious that animals *are* able to select suitable habitats. Some species even appear to be genetically endowed with the ability to recognize appropriate habitat types. For example, a subspecies of the prairie deermouse, *Peromyscus maniculatus bairdi,* occurs naturally in grassy fields. Another subspecies lives in woodlands. To investigate habitat selection in *P.m. bairdi,* Wecker (1963) built an outdoor enclosure 16 feet wide by 100 feet long, with 50 feet in an oak-hickory woodland and 50 feet in a grassy field. A nest box was placed at each end, and the enclosure was divided into a number of compartments. Mice could pass between compartments and move from one end of the enclosure to the other, but only by passing through runways equipped with electrical switches that recorded the time of each passage (Figure 15.1). Thus a record was kept of the amount of time a mouse spent in each compartment, and therefore the time spent in the grassy field or the woodland could be figured.

Wild-caught mice spent most of their time in the grassy field compartments. Offspring of wild-caught mice raised in the woodland end of the enclosure also showed a strong preference for the grassy field area, when they were later allowed access to it. But most impressive was that offspring of wild-caught mice raised in the laboratory, with no woodland or grassy field experience, also showed a strong preference for the grassy field area when released in the experimental enclosure. Thus habitat selection by these mice appears to be genetically influenced.

Habitat selection for animals in nature is probably only rarely as convenient as for the deermice in Wecker's experiment. However, certain aspects of a habitat must provide animals with information on which to base their decisions as to whether to stay or search further, just as the deermice in Wecker's experiment must have detected cues regarding which end of the enclosure would be most suitable. We could guess that the deermice used presence of grass as a cue, and/or absence of trees, but we really don't know.

An animal visiting a prospective habitat must somehow assess not only how suitable it is now, but also how suitable it will be in the future. Resources needed when offspring must be fed often are not present at the time of habitat selection. For example, redwing blackbirds that breed in eastern Washington state are migratory and feed mostly on seeds, except during the breeding season, when they use mostly insects emerging from water to feed themselves and their young. When male redwings arrive in spring and begin habitat selection, few if any of the insects are evident. Therefore the male redwings' assessment of the habitat involves "predicting" whether food for the young will be available later, when it is needed. Again, we do not know what cues are used, but probably the presence of water and of suitable nesting sites are important.

It seems obvious, then, that there is likely to be some degree of error in habitat assessment. Examining a given habitat more carefully may yield additional information and reduce error, but also requires additional time and energy. However, leaving to search for and evaluate another area also takes time and energy, and may increase exposure to predators. Under what conditions should an animal settle in a habitat that is less than optimal? The answer depends upon the risk, the cost-benefit ratio—the probability of success in locating a better habitat weighed against the time, energy, and exposure to predators involved in the search. How near in time is the breeding season? What is the probability of success if breeding is delayed? How much more likely is the animal to be attacked by a predator while searching for another area than while remaining in a habitat that is below optimum quality? And, finally, what is the animal's internal state? For example, hunger would be a signal that good habitats have not been encountered recently, and also that the energy available for further searching may be minimal. As costs increase, we would expect standards for quality to decrease; remaining in a habitat that is less than ideal should become more likely.

The presence of other individuals of the searching animal's species is useful information, because it is evidence (a cue?) that others have made a positive evaluation and are surviving. If the habitat is not too crowded, it may be better to stay than to search further.

Thus animals apparently use cues in habitat selection. These may be learned in some species, by remembering what "home" was like; innate in others, like Wecker's deermice; or possibly some combination of the two

Speculations on Habitat Selection by Humans

In humans the period of offspring dependence is longer than in any other animal. Therefore, a suitable habitat for humans must have resources available on a long-term basis.

Archeological evidence indicates that humans evolved in the tropics, at a time when forests were receding and savannas expanding; that humans, and their dryopithecine and australopithecine ancestors, lived in tropical savannas—grasslands with scattered trees. Thus it is likely that any inherited preferences we might have regarding habitat type were formed primarily in tropical savannas and only slightly modified in the relatively short time we have lived in other areas. We will now take a look at tropical environments in general, and savannas in particular, and compare the quality and quantity of resources they provide.

In forests with dense canopies, most of the food resources consist of leaves and fruit or seeds that are located well above ground level, and therefore are much more readily available to tree-dwelling animals than to ground dwellers such as humans and their ancestors. In savannas, however, trees are smaller and grasses are major producers of energy. Therefore, much of the energy present in savannas is available to grazing animals, which our ancestors used extensively for food. Also, many of the plants of savannas store energy in underground tubers, roots, and stems, which humans could obtain by digging.

Water is essential for drinking, and also has been used extensively for cooking, probably for at least 50,000 years. In many aboriginal cultures people also like to bathe frequently, as we do. Aquatic environments can be good sources of protein, in the form of fish and shellfish. Thus it is not surprising that many archeological sites are found at or near water, as are most aboriginal villages today. Certainly if we were going out to live off the country for an extended period, we would prefer a campsite near a source of water.

Large predators must have been a threat during most of our evolution, and their presence would make the choosing of a safe place to sleep of great survival value. While most humans are no longer threatened by predators, bears still attack people occasionally in the northwestern United States and Canada, and grizzly bears were one of the great dangers faced by the mountain men. Evidence of early human habitation is often found near cliffs and in or near caves. Ledges on cliffs would provide relatively safe sleeping sites for humans, as they do for savanna baboons today. Caves provide protection from weather, and a fire at the entrance would discourage predators. The risk of being surprised by predators is much lower in a savanna than in a forest, because we are much more likely to be able to see them at some distance. Also, most large predators are not good tree climbers, and a savanna has trees that can be used for emergency escape as well as for safe sleeping.

With this background it is now appropriate to address some questions about humans today. How can we investigate what sorts of habitats people would select if they had completely free choice? Which environments would people prefer to live in if they were not constrained by costs? (Note that costs may include leaving a good job and other inconveniences, and perhaps displacing people who already live at the preferred site.) One way of trying to answer these questions is to examine how people feel about various habitat types.

People were already living on most parts of the earth before recorded history, so we have little information regarding which unoccupied areas people would choose. However, there is substantial information in Western literature about the emotional responses of humans to certain habitat types. The forest has been regarded as the home of such unsavory characters as gnomes, trolls, and witches, and is associated with fears and depression.

Prehistoric humans in their cave. Caves provided protection from weather and from predators.

Consider the following observations by historian Roderick Nash (1973):

> . . . I have been arguing that millions of years of life in open environments, relying on vision in the struggle for existence, stamped a lasting bias against wilderness on the mind of protoman and man himself. If this is so, it should be possible to observe the bias lingering even after the advent of civilization. I believe we do find it in our continuing fear of the forest. . . . Take, for instance, the experience of the North American pioneers. In the thick forest of the Atlantic coast they felt uneasy. Account after account describes how the wilderness hemmed man in, frustrating his vision and concealing a host of dangers, both real and imaginary. . . . The pioneers feared and hated this environment. . . . The wilderness was "dark" and "gloomy" or "nightmarish" . . . in league with devils, demons, and the evil forces of darkness . . . that civilization must overcome. . . .
>
> [M]any accounts of westward migration in North America contain expressions of relief on emerging from the Eastern forest wilderness to the openness of the Great Plains. . . . In rhapsodic language, never applied to forests, accounts such as James Hall's *Notes on the Western States* (1838) described the waving grass, the profusion of flowers, the brilliant sunshine. The Midwestern plains, to be sure, were just as devoid of civilization as the Eastern forests, but from the pioneers' perspective they were a different kind of environment. This is evident from the fact that the term "wilderness"

> was seldom applied to the grasslands of the Middle West. "Garden," on the other hand, was frequently employed (pp. ix–xi).

Hills, cliffs, and mountains are attractive to us, and we often have a desire to climb them, or otherwise get "up there" and enjoy the view. Why? Certainly it is behavior that is useful for locating game animals, detecting predators, and otherwise assessing the environment.

Water is also attractive to us. A large body of water adjacent to the city of Seattle—Lake Washington—is about twenty miles long and is used for recreation all year. Permanent residences line its shores. Raw sewage and the output of sewage treatment plants enriched the lake so much that by about 1960 the growth of certain types of algae had changed the color of the lake and caused an unpleasant odor. Voters approved spending $120 million to clean it up by diverting all sewage to Puget Sound, even though water for Seattle households and industry comes from the nearby Cascade Mountains rather than from Lake Washington. Here, as is often the case, water was valued for aesthetic purposes, as well as for its utility. "These emotional responses are so familiar that we take them for granted; it never occurs to us to ask why we feel that way about lakes, rivers, cliffs, and savannas. Why don't other environments affect us that way?" (Orians, 1980a, p. 61).

Prices of residential real estate, which reflect a combination of how much buyers are willing to pay and what sellers require to induce them to part with the property, provide another clue to the sorts of habitats people prefer. A place with a view is worth more than one without. A house is worth slightly more than others if it is simply located uphill from other houses so that it looks down on them. Next comes a house with a "peek-a-boo" view, where a glimpse of hills, mountains, lake, or ocean can be seen from one of the windows. The ultimate in view property has a sweeping view of mountains or the ocean, and is still more valuable if it has both.

Residential property that fronts on water is more valuable than nearby property that does not. Property near but not on water is in turn more valuable than property further removed, unless of course the latter has a view, which complicates matters. But, in general, view property is less valuable than waterfront property.

Public parks offer additional examples of the type of environment people prefer—in this case, environment for relaxation. Parks in all parts of the world resemble savannas, with lots of grass and scattered trees, even though the natural habitat of the area—the habitat in which many of the residents grew up—may be anything from dense forest to desert.

Much of the evidence consistent with an evolutionary-genetic hypothesis for habitat preference in humans is anecdotal and merely suggestive. What is now needed is a research effort that is both systematic and objective if we are to gain an adequate understanding of why there are preferences for particular kinds of habitats. An interesting attempt has been made in this regard by Balling and Falk (1982). They showed slides of natural landscapes—tropical rain forest, temperate deciduous forest, coniferous forest, savanna, and desert—to groups ranging from third-grade elementary school students through senior citizens, and including professional foresters. Elementary school students showed a significant preference for savanna. Those in midadolescence and older showed equal preference for savanna and for the natural environment that was most familiar to them. These results were interpreted by Balling and Falk as providing limited support for the idea that humans innately prefer savanna-like environments as a result of our long evolutionary history in African savannas.

One final quote from Orians is instructive:

> These behavioral tendencies are all well known but they are so obvious that is has not seemed worthwhile to ask questions about them. Yet it is precisely those aspects of our behavior that seem so obvious so as not to require any explanations that are the most likely to reveal the imprint of selective forces that have molded us. As anthropologists have long known, the values of a society that nobody questions reveal most about a culture (1980a, p. 64).

Orians has initiated in-depth research to explore the phenomenon of habitat selection by humans. Perhaps in a few years enough information will have been accumulated so that we can eliminate the first word of the title of this section —*speculations*.

Prosocial and Agonistic Behavior

16

Prosocial Behavior

Agonistic Behavior

Chapter Preview

Prosocial behaviors involve the giving and receiving of benefits — helping, sharing, or cooperating with others. It is becoming common to substitute the term *altruistic* for *prosocial,* but this presents problems. Altruism is often defined as helping others without expectation of reward (benefit), but it is difficult to verify that an act is truly altruistic.

Social exchange theory is based on the idea that we weigh costs and benefits, perhaps unconsciously, when we consider entering or continuing a social transaction. Equity theory stresses the discomfort people often feel if costs and benefits do not balance out, for themselves or others. However, some psychologists believe that people try to maximize benefits for themselves. Justice motive theory holds that the way people react to someone in distress depends upon whether or not they think the person deserves to be helped.

Elements of prosocial behavior appear early in human development. During their first year, babies become upset upon hearing distress signals from others. Sharing has been observed in children as young as eighteen months, and increases as children become older. Observing others behave prosocially, in person or on television, appears to be important for the development of prosocial behavior.

Individuals tend to do what benefits their own survival and reproductive success — their fitness. However, members of many species, including humans, often risk their lives to protect their young, or their family or social group. Kin selection theory holds that fitness involves passing genes to future generations. Thus it is genetically advantageous to help relatives, because they have many of the same genes we have and if enough of them survive they can pass more of our genes to future generations than we can. Reciprocal altruism involves the idea that we are inclined to help nonrelatives because, in our evolutionary past, doing so has brought benefits to the helper.

Agonistic behavior includes threat, counterthreat, attack, counterattack, defense, submission, and escape. It commonly occurs when control of resources is in dispute. *Aggression* can be defined as behavior directed toward others which could lead to their physical injury, and which often results in deciding status or access to resources. Threat may be the most common form of aggression; it is certainly the most economical.

In medieval times aggression was accepted as natural for humans. During the Renaissance it was thought that people are not naturally aggressive, but rather that aggression is learned from the evil and corrupt societies in which we live. Sigmund Freud and Konrad Lorenz believed aggression is instinctive, and that it must be dissipated or it will build up.

The frustration theory of aggression originally held that every frustration produces aggression, and every aggression can be traced back to frustration. More recent views allow for other responses to frustration, but often see a strong and usual relationship between frustration and aggression. Several types of emotional arousal can contribute to aggression.

Social learning theory holds that humans learn how, when, and toward whom to aggress, perhaps mainly from modeling, but at least some social learning proponents recognize that there also are genetic components to human aggression.

Although sometimes equated solely with aggression, warfare consists of other agonistic behaviors as well. Although there are attackers, there are also defenders, and sometimes it is not clear which is which. Frequently warfare develops when one group sees an opportunity to increase its fitness at the expense of another group. Typically, both sides produce propaganda belittling their opponents and attributing terrible characteristics to them, which may make killing them psychologically less difficult.

There are two fundamental forms of social interaction: cooperation and competition. **Prosocial** behaviors are basically *cooperative;* they are associated with giving and receiving benefits. *Competitive* behaviors are of two types, called scramble competition and contest competition (Barash, 1982).

In **scramble competition** resources are sought without any particular regard for competitors; if social interaction occurs it is incidental, and is not a part of scramble competition. **Contest competition** involves the direct interaction of individuals seeking resources, and the outcome of the interaction determines who will have the resources. Contest competition therefore includes *assertive behavior,* for example, expressing self-confidence and/or arguing for one's rights or beliefs, and **agonistic behavior**, meaning threat, counterthreat, attack, counterattack, defense, submission, and escape. Agonistic behavior commonly occurs when control of resources is in dispute.

Prosocial Behavior

We can define prosocial behavior as *helping, sharing,* or *cooperating* with others. Thus prosocial behavior includes a wide variety of acts performed by one or more individuals that benefit one or more other individuals, and may also benefit those performing the acts.

Humans differ from other animals far more in the complexity and development of their prosocial behavior than in their agonistic or sexual behavior. Much of human prosocial behavior is based upon social bonds, which are much more restricted in animals, and will be discussed in the following chapter. But humans also help strangers, which is not known to occur in other animals. Other animals often help relatives; sometimes it is not known what relationship exists between the helper and the helped, but because the animals are together they are usually assumed to be from the same social group and therefore may be genetically related.

It is becoming common in psychology and biology to substitute the term *altruistic* for *prosocial,* but as we shall see there are problems with this substitution of terms. Dictionaries often define *altruism* as helping others without expectation of a reward (benefit). Thus the donor loses while the recipient gains. Losses include time, energy, risked or actual injury, or loss of resources such as food or money.

The psychological study of altruism increased markedly after the infamous murder of Kitty Genovese in March 1964, which received national attention. Genovese was attacked at 3:20 A.M. in a middle-class neighborhood of Queens, New York City, and the attack lasted at least thirty minutes. It is known that at least thirty-eight people heard Genovese's screams and watched the attack from their windows, and yet not one either went to her aid or called the police. Ms. Genovese died of multiple stab wounds.

Kitty Genovese, who was slowly murdered while numerous onlookers did nothing to help.

Several studies purport to show evidence of helping that is not based on expectation of reward. For example, one series of experiments involved pairs of men taking part in a joint endeavor. The first experiment indicated that partners were equally motivated, even though only one was to receive a reward, and they knew in advance which one of them it would be (Berkowitz, 1957). However, there was still the possibility that the unrewarded individuals worked hard in order to gain their partners' approval. In a further experiment, subjects were told that their partners would not be told of their help for several weeks or months. Still subjects worked hard, although they suggested that an incentive for themselves would be desirable (Berkowitz & Daniels, 1963). Of course the possibility remained that subjects were working for the reward of approval from the experimenters, but further tests were believed to rule out this factor (Berkowitz, Klanderman, & Harris, 1964).

The conclusion of the researchers was that there is a social norm for being helpful, and expectation of a reward is not necessary. In other words, the helping was altruistic. However, the subjects in the second experiment were told their partners would learn about their help, although after a delay, and so they could have been working for the reward of partner approval. Thus the evidence does not demonstrate a social norm, but only indicates that the participants appeared not to be working for social approval or reward, according to the researchers' interpretation.

It is impossible to rule out some expectation of reward as reason for engaging in an altruistic act (Berkowitz, 1972). There may be no *observable* gain, but the donor might expect a return of the favor, or at least social approval. Thus, technically speaking the term *altruism* may be a misnomer. Yet many psychologists and biologists persist in equating prosocial acts with altruism, whether or not they believe a reward is expected.

Theories of Prosocial Behavior in Social Psychology

Three of the major theories in social psychology that address prosocial behavior are **social exchange theory, equity theory,** and **justice motive theory** (Lamberth, 1980). None of these theories involves giving without any expectation of return; thus none deals with altruism in the dictionary sense of the term. But all three have something to say about the reasons for various kinds of prosocial acts.

The driver of the car must weigh the benefits of having company and helping someone against the costs in time and risk of danger in deciding whether to give the hitchhiker a ride.

Social Exchange Theory The social exchange theory is based upon the idea that we weigh costs and benefits, sometimes unconsciously, when we decide whether to enter into or continue a social transaction. This can be extended to include a prosocial act involving a stranger. Everyone has social needs and social resources they can use to gain satisfaction of these needs. Both our needs and our resources include such things as helping, friendship, companionship, and social approval. It is often assumed that we attempt to exchange these resources so as to maximize our benefits and minimize our costs. For example, friendship costs time and energy, and if we do not feel we are receiving benefits at least equal to what we are giving we are likely to discontinue the relationship.

Equity Theory Equity theory (Adams, 1963) is an extension of social exchange theory that stresses the discomfort people often feel if costs and rewards do not balance out, whether for themselves or others. In other words, members of any social group are most comfortable when there is equity for all. This is indicated by the fact that groups generally reward members who treat others well, at least with social approval, and assess costs against those who treat others unfairly.

Walster, Berscheid, and Walster (1973) formalized some of the propositions of equity theory, three of which are especially pertinent to our discussion.

1. People attempt to maximize their outcomes (where outcomes equal rewards minus costs). In this context, *outcomes* are simply observed consequences of behaving in a particular way in a social relationship. *Rewards* are positive outcomes, those that benefit the individual in some way; *costs* are negative outcomes. A corollary of this proposition is that people will behave equitably, as long as they perceive that they can maximize their outcomes by doing so.

2. People who perceive that they are participating in inequitable relationships become distressed. As perceived inequity increases, so also does distress.

3. Subjective distress, resulting from perceived inequity, motivates attempts to restore equity. The greater the perceived inequity and subjective distress, the harder people will try to restore equity.

It should be clear that in the context of equity theory, prosocial behavior occurs for basically selfish reasons.

Equity theory has been offered as an explanation for a broad range of social phenomena, not just prosocial behavior. It is particularly well-suited for analyzing the dynamics of interpersonal relationships, including those of a romantic nature, and for predicting the factors that tend to jeopardize such relationships. Equity theory has received a good deal of research support (Freedman, Sears, & Carlsmith, 1981; Shaw & Costanzo, 1982), and its cost-benefit approach is similar to evolutionary explanations of social behavior, as we shall see.

The Justice Motive The justice motive theory is related to equity theory, and holds that the way people react to a person in distress depends upon whether they think the person deserves to be in such a situation. For example, you might not feel like helping someone in trouble if you had earlier seen that person beating a child, but you might feel differently about helping someone whom you had seen stop the beating.

The difference between equity theory and justice motive is not always clear, and some psychologists consider them to be "essentially identical" (Freedman, Sears, & Carlsmith, 1981, p. 295). However, Freedman and colleagues, in explaining the theory, note: "People tend to believe that every human being deserves at least some minimum share of the world's resources. . . . But we also believe that people who make an effort deserve more than those who do not. . . ." (p. 295). It seems clear that the first statement refers to equity, the second to justice.

Development of Prosocial Behavior

Newborns are motivated primarily, and perhaps totally, by the desire to satisfy their needs. This is most obvious to us in human newborns, who are totally dependent and helpless, although they are equipped to give signals (crying, smiling) to caregivers and stimulate their aid.

During their first year babies become

upset upon hearing distress signals from others. This has been called empathic distress; the baby recognizes distress signals but presumably does not realize it is someone else who is in distress (Sagi & Hoffman, 1976).

Sharing without being prompted or praised has been found in children as young as eighteen months of age (Rheingold, Hay, & West, 1976). In groups of normal and retarded children ages three to five and eight to ten, it was found that 35 to 57 percent of opportunities to help others were taken (Severy & Davis, 1971). Sharing and helping increase in normal children during the elementary school years, along with a general increase in social activity and a developmental shift from egocentric to reciprocal behavior (Shaffer, 1979). But what accounts for this age-related increase in prosocial behavior?

Hoffman (1975), unlike most social psychological theorists, has proposed that there is a basic altruistic motive, and that it develops during childhood. According to Hoffman, the basis for altruism is empathy for those in distress, and its development is tied to the cognitive development of the child. In the first developmental stage (birth to two years), empathic distress occurs when the infant has acquired the object concept (see Chapter 14), and realizes that persons as well as objects have an existence independent of the infant's own. During the second stage (two to four years) the child develops the concept of role-taking (being able to adopt the perspective of another), and becomes increasingly aware of the emotional states of others. In the third stage (six to nine years) the child begins to realize that other people have distinct identities and feelings, and this awareness enables the child to behave altruistically.

The older child encouraging the younger child in this activity is an example of prosocial behavior.

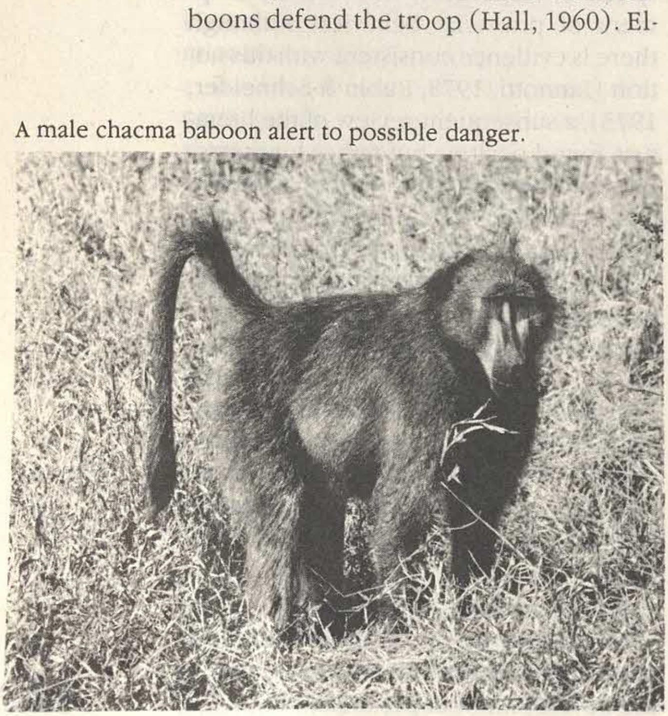
Are cognitive factors such as empathy and the ability to adopt another's perspective responsible for the development of prosocial behavior? Although there is evidence consistent with this notion (Iannotti, 1978; Rubin & Schneider, 1973), a subsequent review of the literature found positive but rather low correlations between prosocial behavior and perceptual, social, and moral perspective taking. Surprisingly, there was no overall significant relationship between prosocial behavior and empathic perspective taking (Underwood & Moore, 1982). This finding seems somewhat damaging to Hoffman's developmental stage model. Underwood and Moore suggest that perspective taking may be only one of many variables responsible for mediating the development of altruism.

One mediating variable is apparently social learning. Observing others behave prosocially appears to be important for the development of prosocial behaviors, and parents who expect their children to "do as I say, not as I do" may be quite unrealistic. For example, young children tend to imitate prosocial behavior observed on television (Rubinstein, 1979). Also, films showing prosocial behavior are more effective than moral exhortations in inducing third- and fourth-grade children to perform prosocial acts (Bryan & Schwartz, 1971). Thus we see that prosocial behavior develops as the child grows, that it may be related to certain aspects of cognitive development, and that it can be influenced by prosocial models.

Evolution of Prosocial Behavior

Prosocial behavior is not unique to humans; it is a characteristic of many other animals as well. Several examples will make the point. Porpoises are said to aid an injured porpoise by raising it to the surface, where it can breathe. Male baboons defend the troop (Hall, 1960). Elephants reportedly attempt to aid sick or injured elephants. In many bird species a breeding pair is helped in nest building and feeding the young by other, unmated adults (Emlen, 1978), and similar behavior has been attributed to wolves. Ground squirrels give alarm calls that warn others of danger, but can also attract attention to the warning individual (Sherman, 1977). Why have these characteristics evolved?

A male chacma baboon alert to possible danger.



Individuals of many species, including humans, often risk their lives to protect their young, or their family or social group. At first glance this seems to violate evolution theory, which holds that individuals tend to do what benefits their own survival and reproductive success. In other words, individuals are expected to behave selfishly; otherwise they will be contributing to someone else's fitness rather than, or more than, their own. Documented instances of prosocial behavior proved embarassing for Darwin's notion of natural selection until relatively recently, when Hamilton (1964) advanced the theory called kin selection.

Kin Selection The idea that it is advantageous to help one's relatives is called **kin selection** (Figure 16.1). Biologically speaking, reproductive success is the final proof of fitness. Each of us comes from a long line of successful reproducers; if someone along the line had been unsuccessful in reproducing, that line would have stopped, and some of us wouldn't be here to talk about it. To put it on a more personal basis, if your parents hadn't reproduced, you would not exist. Reproduction consists of a sperm (a packet of genes) and an ovum (another packet of genes) uniting and developing into a new individual. So we can think of fitness simply as the probability of getting our genes into the next generation.

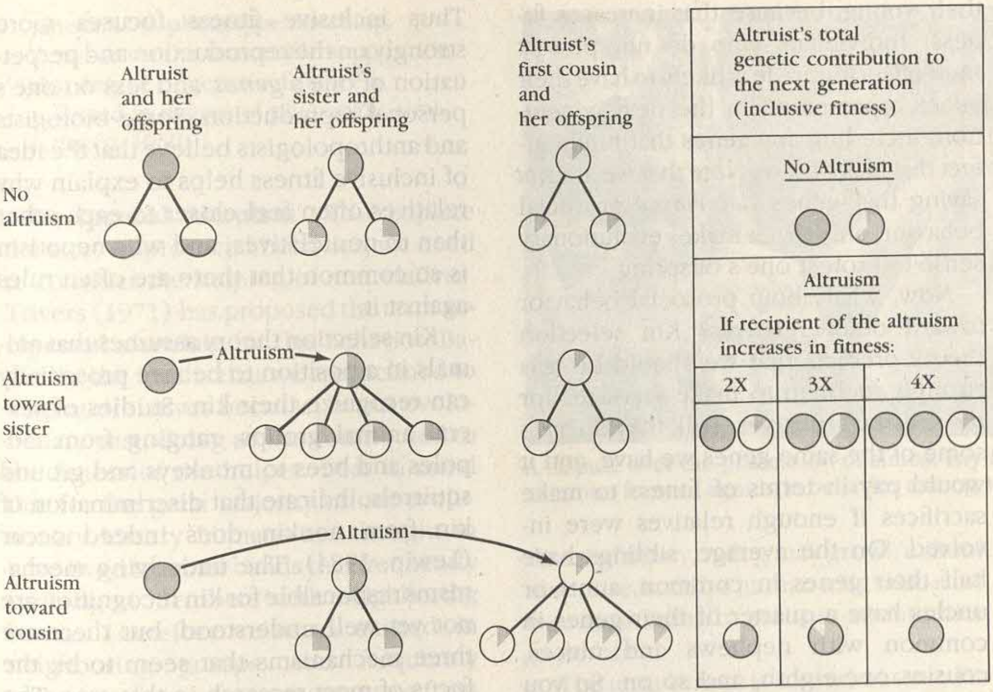

Altruist and her offspring
Altruist's sister and her offspring
Altruist's first cousin and her offspring
Altruist's total genetic contribution to the next generation (inclusive fitness)
No altruism
No Altruism
Altruism
If recipient of the altruism increases in fitness:
2X
3X
4X
Altruism toward sister
Altruism
Altruism toward cousin
Altruism

Figure 16.1 Kin Selection. One possible way in which altruism could be perpetuated genetically. The colored parts of each circle represent the altruist's genes. The altruist's sister would share approximately half the altruist's genes, and the altruist's first cousin would share approximately one-eighth of the altruist's genes. The altruist's genetic contribution to her own, her sister's, and her cousin's offspring is shown for three conditions: no altruism (top row); altruism toward sister only (middle row); altruism toward cousin only (bottom row). For the sake of simplicity it is assumed that altruism reduces the fitness of the altruist by a factor of two, but increases the fitness of the recipient by the same factor. The boxed-in colored circles in the right-hand column also show the altruist's genetic contribution when altruism increases the recipient's fitness by factors of three and four (the altruist's fitness is still assumed to decrease by a factor of two). Two things should be clear from this kin selection model. First, any genes for altruism could be passed on genetically, even if the altruist has no offspring, provided she directs her altruism toward relatives and provided the altruism really does increase the recipient's fitness. Second, in general, altruism toward more closely related kin would be more likely to increase the fitness of the altruist than altruism directed toward distant relatives or strangers.

Since relatives have copies of many of the same genes, one's genes can be passed to future generations by relatives.

Offspring each carry 50 percent of each parent's genes, and can be viewed genetically as the parent's investment in future generations. Protecting offspring therefore increases the probability that one's genes will be represented in future generations; protecting offspring increases fitness. Viewed in this way, prosocial behavior makes evolutionary sense—at least prosocial behavior directed toward offspring. Natural selection *should* favor those who protect their young, because that increases fitness. Individuals who do not protect their offspring are less likely to have their genes represented in the next generation, including any genes that might affect this lack of care. Note that we are *not* saying that genes *determine* prosocial behavior, only that it makes evolutionary sense to protect one's offspring.

Now, what about prosocial behavior toward other relatives? Kin selection theory predicts that we should be less strongly inclined to make sacrifices for more distant relatives. Still, they do have some of the same genes we have, and it would pay in terms of fitness to make sacrifices if enough relatives were involved. On the average, siblings have half their genes in common, aunts or uncles have a quarter of their genes in common with nephews and nieces, cousins one-eighth, and so on. So you would usually break even genetically by dying for two brothers or eight cousins. You would be ahead by dying to save three brothers or five nieces or nine cousins, because they probably have more copies of your genes than you do. For example, if you have three brothers, they can be expected to have a total of 150 percent of the genes you have (see Figure 16.1).

Of course, dying for your relatives is an extreme example, and is rarely necessary. Merely helping is often sufficient, but the cost-benefit calculations are similar. The cost to you should be less than the benefit to your relatives or it doesn't make (biological) sense to help them. You probably wouldn't pay fifty dollars to save your sister five, but you might well pay five to save her fifty.

Here we meet a relatively new term, **inclusive fitness.** Inclusive fitness involves personal fitness, but also *includes* the reproductive success of relatives. Thus inclusive fitness focuses more strongly on the reproduction and perpetuation of one's *genes,* and less on one's personal reproduction. Some biologists and anthropologists believe that the idea of inclusive fitness helps to explain why relatives often feel closer to each other than to nonrelatives, and why nepotism is so common that there are often rules against it.

Kin selection theory assumes that animals in a position to behave prosocially can recognize their kin. Studies of several animal groups, ranging from tadpoles and bees to monkeys and ground squirrels, indicate that discrimination of kin from nonkin does indeed occur (Lewin, 1984). The underlying mechanisms responsible for kin recognition are not yet well understood, but there are three mechanisms that seem to be the focus of most research in this area. The first, called *spatial distribution,* actually involves recognition of nests rather than individuals. For example, a parent bird may identify chicks as her own because they are in her nest. The second mechanism — *association* — applies mainly to sibling recognition. The idea is that animals reared together learn to recognize one another as siblings. This appears to be a form of imprinting and is quite common in nature. The third mechanism, known as *phenotype matching,* may account for forms of kin recognition that the other mechanisms do not explain. Lewin describes this form of kin recognition:

> An animal learns what a relative should look like, by, say, using itself or its mother as a referent, and then categorizes others according to how they match with this template phenotype. It is a learning process of the type that psychologists have for years called stimulus generalization. As a kin recognition

> mechanism, phenotype matching depends on the reasonable supposition that degree of genetic distance is reflected in degree of phenotypic similarity (p. 1050).

Reciprocal Altruism To complete the story of prosocial behavior, we need to consider the helping of nonrelatives. Trivers (1971) has proposed the term **reciprocal altruism** for this behavior. Basically, the idea is that we are inclined to help nonrelatives because, in our evolutionary past, doing so has contributed to the fitness of the helper. Bear in mind that for the great majority of our evolutionary history humans are thought to have lived in small bands that frequently exchanged members with neighboring bands. Therefore relatives existed in neighboring groups, and frequently some members of one group were from another, nearby group. A man in one band might be the son of a woman from a neighboring group, in which case he may have aunts, uncles, and cousins in that group. In that setting, a stranger was likely to live nearby and be able to return a favor, and in fact was possibly not too distantly related. But, the argument continues, prosocial acts toward unrelated individuals should "cost" the helper less than they would benefit the recipient.

Agonistic Behavior

As we mentioned earlier, *agonistic behavior* is the type of contest competition that includes *threat, counterthreat, attack, counterattack, defense, submission,* and *escape.* Agonistic behavior commonly occurs when control of resources is in dispute.

A threat is an indication of an impending event that is undesirable, such as a threat of injury. A dog may growl, a skunk may raise its tail, a human may raise a fist, frown, or verbally indicate an intention to do harm.

A dispute over the possession of almost any item is a common form of agonistic behavior among small children.

The term *attack* is sometimes used to indicate a verbal assault, but here we mean an attempt to inflict physical injury. Frequently, both the attacker and the attacked are injured, and injury often decreases fitness. Therefore, most animals, including humans and groups of humans such as nations, do much more threatening than attacking.

Defense, submission, and escape are attempts to avoid or minimize injury. Defense is usually considered to be a physical, combative response to attack, but may be a verbal or gestural response to a threat. Submission is a gestural or verbal sign of relinquishing control, while escape abandons the resources to the aggressor, the one who threatened or attacked.

Aggression

Aggression, a subset of agonistic behavior, apparently means somewhat different things to different people, since almost every definition that has been offered has a different connotation. In psychology and biology, definitions of aggression usually imply or specify attack with the goal of injuring (hurting) others. However, such definitions are too narrow because they tend to exclude threats, which so often result in resolution of conflict without resort to violence. Also, the goal of a threat is not physical injury, but rather obtaining the resource under dispute *without* resorting to attack and without risking injury.

Threatening rather than attacking makes good evolutionary sense because it has good survival value. For example, suppose a wolf is eating a piece of meat and a strange wolf comes along and shows interest in the meal. The wolf that is eating stops momentarily, makes threatening sounds and gestures, and the other wolf goes away. By threatening, the wolf risked little and kept its meal. Now suppose the wolf had attacked the stranger and driven him away, but had suffered a broken leg or a cut in the process. A predator with a broken leg isn't very effective at his profession, and will probably starve to death. A cut may become infected and result in serious illness or death; seriously ill predators aren't very effective either, and may starve or be killed by other predators. In either case the attacker suffers heavy cost and only temporary benefit. The same scenario might apply to a human hunter or trapper, or to anyone else. Although the attacker may not be injured, the advantage of using threat is clear: there is less risk of injury and there is far less energy expenditure. Threat is a more economical means of gaining or maintaining control of resources.

We define **aggression** as behavior *directed toward others* that could lead to their *harm,* and that often results in deciding *status* or *access to resources* (modified from Hinde, 1970). Thus an aggressive act does not necessarily result in physical harm, although it may cause harm due to loss of resources. A **resource** is here defined as anything in the environment that contributes to fitness, including such things as food, shelter, breeding or nesting sites, mates, and space. Generally, resources that are contested are in short supply. Thus, although oxygen is a resource it is plentiful in terrestrial environments and there would be no point in contesting for it.

Status refers to one's position in the dominance hierarchy of a group. This was first discovered in chickens, and called "peck order" (Schjelderup-Ebbe, 1935). It is now known to exist in a number of species, and of course is well known among humans. In species where a dominance hierarchy exists, higher-status individuals have greater access to resources than do those of lower status. This is primarily because lower-status individuals are submissive to those of higher status.

Aggression: Good or Bad?

In medieval times it was accepted that humans have an "animal" nature, and in particular that aggression and sex are natural and inevitable parts of our makeup. Thus being "good" did not involve behaving nonaggressively or nonsexually, but rather behaving aggressively and sexually in socially accepted ways. Strict religious and moral codes were regarded as necessary to keep this animal nature within bounds, or try to.

During the Renaissance the idea evolved that humans do not have an animal nature, but are basically different from animals. People were viewed as not

Societal views of aggression are mixed. The sport of boxing involves aggressive encounters that are condoned and, occasionally, highly reinforced by society.

Modern warriors and some of their battle equipment.

naturally aggressive; rather, it was argued that they learned aggressive behaviors from the evil and corrupt societies in which they lived. Aggression could be eliminated, the reasoning continued, if it weren't learned, or taught. Thus humans were seen as basically nonaggressive but corruptible, even though they produced those evil and corrupt societies.

Contemporary societies are generally ambivalent toward aggressive behavior. There are penalties for aggression within the group, although competition is encouraged. In most groups there is rather extensive competition for wealth, status, and mates, and once one or the other of the first two is attained, the third is almost automatic. But overt aggression usually is not an acceptable means of obtaining needs or attaining goals. The fact that societies have rules and penalties against aggression indicates it is a recurring problem.

The other side of the coin is that aggressive behavior used to hunt, to compete in "contact sports," to kill predators, or to subdue other human groups who are designated as enemies is rewarded. So when aggression is of a type that is acceptable to society, it is considered good. In fact, a strong program for teaching nonaggression could result in failure to respond to an outside threat, and elimination of the group. Thus we receive and transmit mixed messages about aggression.

Theories of Aggression

Biological Theories Sigmund Freud believed humans have an innate aggressive drive, resulting from a death instinct or death wish — an instinct to kill themselves. Aggression is turning the death instinct toward others, according to Freud. Thus aggression is instinctive, and Freud believed that it must be released in some controlled way or it will build up and eventually manifest itself in an uncontrolled way. These ideas would seem to run counter to evolutionary thinking. It is difficult to imagine how natural selection could favor a characteristic whose function is self-destruction, or one that requires aggression even when there is no need.

Konrad Lorenz also believes aggression is instinctive. In his book *On Aggression* (1966) he reviews numerous examples of animal behavior, and points out some striking parallels with human behavior. However, his transition from aggression in animals to aggression in humans is not entirely convincing. Lorenz concludes that humans are instinctively (innately) aggressive. Humans have not developed instinctive mechanisms for "turning off" aggression as other species have, he argues, and therefore aggressive tendencies accumulate and must be released. He theorizes that these factors are the cause of war. Lorenz recognizes that people can and do learn to control aggression, and suggests that if we can find sufficient and appropriate controls and outlets, then war could be avoided.

There is some experimental evidence that aggressive tendencies do seem to build up in a few species of animals — for example, in Siamese fighting fish and in fighting cocks, which have been artificially selected (by humans) for increased fighting behavior. However, aggressive tendencies do not accumulate in the vast majority of animals. Except in very special ecological circumstances, this behavior is clearly not adaptive. Such an instinct would dictate that even animals with ample resources must go out and find someone to attack, and we have already pointed out that attacking others unnecessarily reduces the probability of survival. However, the *capacity* to behave aggressively *when necessary,* as is the case with most species of animals including humans, is obviously more conservative of energy, involves much less risk than indiscriminate aggression, and would seem to be of high selective value.

Note the similarity between Freudian and Lorenzian views of aggression. Both asserted the need to release pent-up aggressive impulses. Both also believed aggression can be sublimated, and released in socially acceptable ways.

Arousal and Aggression The **frustration-aggression theory** was introduced by Dollard, Doob, Miller, Mowrer, and Sears (1939). It holds that every frustration produces aggression, and that every aggression can be traced back to frustration. According to this view, frustration arises from the blocking of an ongoing goal-directed activity. The frustration-aggression theory has since been modified to allow for other responses to frustration, but its adherents believe that frustration and aggression have a strong and usual relationship.

The frustration hypothesis is appealing because "everybody knows" frustration leads to aggression. However, experimental results are far from conclusive. Some experiments have shown an apparent cause-effect relationship, but a large number of these experiments are of doubtful validity, and some included other arousal stimuli in addition to frustration. Other experiments show no relationship, and still others have found aggression was *reduced* following frustration (Baron, 1977). Sometimes people simply withdraw or try harder in response to frustration.

It seems probable that frustration sometimes leads to aggression, but under what conditions? One possibility is that frustration may need to be felt very strongly for aggression to result. There is some support for this view, since research that has supported the frustration-aggression theory has generally used stronger levels of thwarting than has research yielding negative results (Baron, 1977). Another possibility, supported by several research studies, is that frustration due to obstruction that is viewed as arbitrary or unexpected may induce higher levels of aggression. In fact, there is some indication that obstruction that is expected, or seen as fully justified, often fails to result in aggressive behavior or even arousal. If, as Baron suggests, intense frustration is relatively rare, and when it does occur is often expected, then frustration may not be a very common cause of aggression.

There is another aspect of the frustration-aggression hypothesis. According to Dollard et al., aggression following frustration can be reduced either by removing the cause of frustration or by aggressing. If aggressing occurs, arousal is reduced and catharsis ("cleansing") results. If aggressing does not occur a residue is left, and residues build up. This idea is similar to one aspect of the hypotheses of Freud and Lorenz. Thus an aggressive "drive" is indicated by these researchers. However, research evidence suggests that although aggressing may sometimes result in catharsis, it may also lead to further aggression (Geen & Quanty, 1977).

This man appears to be highly frustrated. Frustration may lead to aggression under certain conditions.

Emotional arousal other than frustration also can affect aggression, but much less research evidence is available. Anger, as we might expect, increases aggression, and more so when paired with frustration or other emotional arousal. As Berkowitz (1969) points out, the usual or common reaction to frustration is anger, not aggression, but aggression can follow if suitable cues are present.

The term *general emotional arousal* is commonly used to include conditions other than frustration or anger. One of these is sexual arousal, and another is the arousal that results from strenuous exercise. If a person is aroused in one of these general ways and then angered, aggression appears to be greater than it is in response to anger alone.

Social Learning Theory Bandura, the prominent proponent of social learning theory, recognizes that there are biological and thus genetic aspects to aggression and other behaviors (1979). He points out that we are predisposed to perceive and learn certain features of our environments, and that we possess neurophysiological mechanisms that enable us to act aggressively, noting that "an insult will generate activity in the hypothalamus" (p. 320). However, "the specific forms that aggressive behavior takes, the frequency with which it is expressed, the situations in which it is displayed, and the specific targets selected for attack are largely determined by social learning factors" (p. 321). While recognizing genetic influences, Bandura argues that aggressive behavior is *mainly* subject to appropriate cues, and is under cognitive control.

Numerous experiments by Bandura and others show that aggressive behavior can be learned from models and can be increased or decreased according to rewards or punishments the model receives. It is also known that the perceived status of the model affects the degree of modeling. For example, in a series of experiments (Bandura, 1965; Bandura, Ross, & Ross, 1961, 1963a, 1963b) nursery school children observed models aggressing against an inflated plastic clown — hitting it, kicking it, sitting on it, and beating it with a hammer. The children were then put in a room with toys, including the plastic clown. Results of several experiments showed: (1) boys imitated male models more, girls imitated female models more; (2) children who had seen the aggressive model were more aggressive than members of a control group who had not; (3) children who saw the aggressive model rewarded aggressed more than those who saw the model punished; (4) those who saw the model punished aggressed less than those who saw neither reward nor punishment; and (5) children could recall more of the model's aggressive behavior than they displayed, indicating that they had learned the behaviors even though they did not use them.

How, when, and against whom to aggress apparently are learned, while the capacity to aggress may be genetically influenced.

According to social learning theory, aggressive behavior in our day tends to be learned largely from three sources: the family, the subculture, and the mass media, especially television. Studies show that children whose parents use aggressive solutions to problems also tend to be aggressive (for example, Bandura & Walters, 1959). In certain communities fighting is valued (Short, 1968).

And numerous studies of televised aggression suggest that it not only teaches how to aggress (Bandura, 1973) but it also may blunt sensitivity to violence by habituating people to violence (Thomas, Horton, Lippincott, & Drabman, 1977), and cause viewers to overestimate the amount of violence in real life (Gerbner, Gross, Eleey, Jackson-Beeck, Jeffries-Fox, & Signorielli, 1977).

Evaluation of the Theories There is no convincing evidence that humans have an innate aggressive *imperative,* as suggested by Freud and Lorenz. A great deal of evidence indicates that we learn how, when, and toward whom to aggress from the society in which we live. But even Bandura (1979), who has emphasized observational learning, recognizes that there are also genetic components to human aggression.

Humans appear to learn methods of aggression about as readily as we learn language, and we are rather easily stimulated to create situations that lead to aggression (Tiger & Fox, 1971). We saw in Chapter 9 that the limbic system is an old part of the brain, and that certain features associated with aggressive behavior are apparently influenced or controlled there. These observations, together with a fairly extensive literature on genetic, hormonal, and neurochemical influences on aggression (Whalen & Simon, 1984) suggest that aggressive behavior has some basis in heredity. It is likely that we have innate *capacities* to aggress and a readiness to learn various forms of aggression, and that these factors contribute to our fitness.

Warfare

War is commonly thought of as an example of aggression, but it is more proper to classify it as agonistic. It is true that in war there are attackers, but there also are defenders. Furthermore, the attacker may initiate combat in response to activities by the enemy that the attacker viewed as aggressive, and may therefore regard the attack as defensive. For example, the country of Israel exists in territory that is also claimed by the Palestinians. The Palestinians view their terrorist activities as a legitimate response to Israel's occupation of their homeland. Israel, on the other hand, insists its attacks on Palestinian bases are necessary responses to terrorist attacks. Neither considers itself an aggressor.

Frequently warfare develops when one group sees an opportunity to increase the fitness of its members at the expense of another group. War is usually preceded by facilitation ceremonies, such as war dances, parades, or political rallies. By means of these activities the warrior sees that other members of the group will contribute to the war effort, and that since society supports the war effort it must have value to the society.

It is common in warfare for each side to produce propaganda that both belittles and attributes terrible characteristics to the opponents. If opponents are viewed as subhuman or akin to predators, then killing them may not be quite like killing other people. This propaganda technique is all the more effective if the enemy belongs to a different race, and so looks "different." It is interesting to note in this connection that many aboriginal groups refer to themselves as "the people" or some similar designation; the implication is that those outside the group are in some sense less than human. Thus they tend to exhibit xenophobia, just as we do, a distrust or dislike of strangers or foreigners, a tendency to categorize people as "us" and "them" that aids in the acceptance of propaganda.

Warfare and other requirements of courageous acts may be ways of dealing with and even exploiting the restlessness of youth. Tiger and Fox (1971) have this to say:

> The traditional way of dealing with the aggression and frustration of the young male is to direct it outward. The peripheral primate is the first to deal with predators, and the young warriors the first to face the enemy and die. The Crow [Indians] again show how aggression can be turned to advantage by making the war game into a status race. To get into the male hierarchy, the young•brave had to perform certain feats of courage and cunning that could be validated before his elders. His energies were directed outward toward the foe rather than upward toward his own superiors. Furthermore, he had to joust with death if he wanted to become an important male. Universally it is the old men who make the rules, own the teams, promote the boxing matches; it is the young men who leap at barbed wire, concuss one another, and devote more physical energy now than at any other time in their lives to attempts to outdo one another (p. 111).

Comment

Since at least as early as the Renaissance it has been suggested that humans are not innately aggressive. Those who believe aggression is entirely learned often point to the few known societies that are extremely pacific as evidence that aggression is not genetically influenced. But Margaret Mead (1969) argued that we need some training in aggression to learn how to control it:

> . . . there is increasing evidence that there may be a negative correlation between the amount of experience in childhood with aggressive behavior that falls short of serious damage and the amount of violence that may erupt in that society. Those societies where children receive no training in limited conflict with others have the least experience in halting destruction and killing once it starts (p. 229).

The peaceful Semai of Malaya detest violence, are known for their lack of aggressiveness, and do not even punish their children. Yet Dentan's description (1968) of their response to conflict would seem to bear out Mead's point:

> Many people who knew the Semai insisted that such an unwarlike people could never make good soldiers. Interestingly enough, they were wrong. Communist terrorists had killed the kinsmen of some of the Semai counterinsurgency troops. Taken out of their nonviolent society and ordered to kill, they seem to have been swept up in a sort of insanity which they call "blood drunkenness." A typical veteran's story runs like this. "We killed, killed, killed. The Malays would stop and go through people's pockets and take their watches and money, we did not think of watches or money. We thought only of killing. Wah, truly we were drunk with blood." One man even told how he had drunk the blood of a man he had killed (p. 59).

17

Affiliation, Bonding, and Sex-Related Behaviors

Affiliation

Bonding

Sex-Related Behaviors

Chapter Preview

Affiliation begins when an attraction develops between individuals, and it can develop into a positive close relationship — a bonding. Studies of interpersonal attraction yield little information regarding what attracts one person's attention to another person in natural situations. But data from questionnaires and brief arranged encounters indicate that college students rate facial attractiveness as most important, and attitude similarity next, in finding another attractive in these artificial situations.

Friends are usually of the same age, race, and sex, but we have little information about how friendships are formed or terminated. Friends characterize each other as persons with whom they share activities, experiences, and interests, who are comfortable to converse with, and who are accepting, dependable, supporting, and understanding.

Love is a term that is used in a variety of ways. It may be used to indicate preferences, or the feelings we have for friends or relatives, or romantic relationships. Romantic love is a type of mating bond from which a pair bond may develop.

Pairs of chimpanzees form mating bonds while the female is in estrus. Many species of mammals and birds form a pair bond during the breeding and nesting season and cooperate in caring for the young. Many mammals form permanent pair bonds and cooperate over a period of years.

The mother-infant bond is basic to the formation of other bonds later. The quality of this bond has profound effects on the child's behavior.

A number of differences between male and female humans exist. These include differences in certain physical traits, cognitive skills, and social behaviors. Many of the differences may be related to the sexual division of labor so pronounced in human hunter-gatherers, with males doing most of the hunting and defending, and females investing more in nurturing offspring.

Males and females of sexually reproducing species show certain understandable differences in their selections of mating partners. Males tend to be less selective. They manufacture millions of sperm and are capable of fertilizing a large number of females. The more females they fertilize, the more offspring they help produce, and the more genetically varied their offspring. The situation is quite different for females. A female can produce only a limited number of offspring, each requiring great energy expenditure, and it is important that she be concerned with the quality of her mating partner. One way for a female to judge the quality of a male is by the resources he controls.

Mates can be viewed as resources. Each mate supplements the functions of the other, and, in humans, a union may consolidate other resources. We are most familiar with monogamy, but polygyny—being mated to more than one female—exists in many societies. It can be advantageous for a female to enter into a polygynous relationship if it enhances the opportunity of success for her offspring.

Incest taboos are almost universal in human societies, possibly due to the relatively high frequency of mental and physical deficiencies in the offspring of close relatives. Interestingly, people who grow up together are generally not interested in each other sexually, particularly as marriage partners, whether biologically related or not.

Affiliation

> No matter how much we deny it, we find that at every stage of life we move toward others—to parents when we are a child, to peers when we are adolescents, to possible sexual partners when young adults, to appropriate communities when adults, and to retirement communities when we are older—on to our death.
>
> We need others. We need others to love, and we need to be loved by them. There is no doubt that without it, we too, like the infant left alone, would cease to grow, cease to develop, choose madness and even death (Buscaglia, 1972, pp. 83–84).

We can define **affiliation** as bringing or receiving *another person* into *close association.* Wanting to be close to another can occur for a variety of reasons. For example, fear may increase the motivation to affiliate, as shown in a classic study by Schacter (1959). In this study two groups of college women were told they were going to receive electric shocks as part of a research investigation. However, the instructions, the demeanor of the researcher giving the instructions, and certain experimental paraphernalia differed for the two groups. A stern-looking researcher seated next to an apparent shock-generating apparatus told subjects in the "high-fear" group that they would receive painful electric shocks. The "low-fear" subjects were told they would receive very mild electric shocks, and that these would not be unpleasant in any way. The researcher instructing the low-fear subjects appeared relaxed, and there was no apparatus present.

Following the instructions, subjects in each group were informed there would be a 10-minute delay while the apparatus was being prepared for the experiment, and were asked whether they preferred to wait alone or with others. After responding the subjects were debriefed—there would be no experiment on electric shock after all; the real purpose of the study had been to observe the effects of fear on the desire to affiliate.

The dependent variable in this study was, of course, the choice of the subjects to wait with others or alone. Results showed that approximately two-thirds of the high-fear subjects preferred to wait with others, to affiliate. Only a third of the low-fear subjects preferred to wait with others. None of the women in either group knew each other, and so it would seem that the desire to affiliate was increased by the greater stress associated with the high-fear condition. Schacter's research shows that induced fear can increase the tendency to want to affiliate, even with perfect strangers. However, in many situations the desire to affiliate is preceded by varying degrees of interpersonal attraction rather than by fear.

Interpersonal Attraction

In a survey of the literature for the years 1974–76, Huston and Levinger (1978) found 403 studies of attraction, most of which used college students as subjects. Two-thirds of the studies were concerned with subjects' impressions of others, and about half of these involved no personal contact. Typically, subjects were handed standardized information about an imaginary person and asked to rate their attraction to that person. In this situation the subject is rendered both passive and passionless (Huston & Levinger, 1978), since the information is removed from the usual natural context—the presence of the other person and an opportunity to interact. The other half of these studies were done using brief, arranged contacts. Thus we still have little information about what attracts one to a certain person more than to others in a *natural* setting. Moreover, the generality of the results of these studies is limited because relatively little information is available for people of other ages, or for

The late Soviet leader Leonid Brezhnev and companion appear to find Jill St. John attractive.

people of college age who do not attend college.

In spite of their shortcomings, results of these and other studies support what you might suspect. Attraction is primarily based on physical, especially facial, criteria, and secondarily on attitude similarity.

Pretty women and handsome men are the most attractive to others, at least initially. When members of the opposite sex are being considered, however, looks are more important to men than to women (Morse, Gruzen, & Reis, 1976). Men are even more strongly attracted to pretty women if the men have been aroused by fear just before the encounter (Dutton & Aaron, 1974). You will recall that aggression is often strengthened by other forms of arousal, and it appears that the interaction of emotions can also increase attraction to another.

Although facial attractiveness may be important in first impressions, it may not sustain a relationship without attitude similarity. However, facial attractiveness does bring preferential treatment, especially by the opposite sex. For example, the quality of an essay was rated highest when subjects believed it to be the product of a physically attractive person (Anderson & Nida, 1978). Physically attractive people also tend to receive lighter penalties from juries (Landy & Aronson, 1969), unless it appears they used their good looks in the crime, in which case they are treated more harshly than others (Sigall & Ostrove, 1975).

Friendships result in many happy experiences.

But why should an attractive face elicit preferential acceptance and treatment? One suggestion is that an attractive face has aesthetic appeal, and thereby causes a favorable feeling. Another proposal, which has received some research support, is that people attribute other positive qualities to facially attractive individuals, in the belief that beauty is really more than skin-deep. For example, Dion, Berscheid, and Walster (1972) found that both sexes thought facially attractive members of either sex would be more kind, interesting, outgoing, poised, sexy, sociable, strong, and successful in work and marriage than less attractive individuals would be.

These suggestions give us some idea of *how* people feel about someone with an attractive face, but they don't tell us *why* they feel that way. Perhaps attractive facial characteristics tend to reflect physical and mental good health. Symons (1979) makes this argument in suggesting that certain physical features in women are considered attractive to men in most cultures. Especially important are tendencies toward plumpness, cleanliness, and a tanned complexion. According to Symons these features may be considered attractive because they tend to be associated with good health and, possibly, with status. Perhaps we are predisposed through natural selection to learn to recognize and favor characteristics associated with health and status.

Since beauty is in the eye of the beholder, and much of the research has used *pictures* of faces, it is possible that the conclusions emphasizing the importance of physical characteristics generally, and facial features specifically, are misleading. Different results might have been obtained if judges or subjects had viewed behaving persons, or even full-figure photographs.

Although physical characteristics and attitude similarity undoubtedly play significant roles in influencing interpersonal attraction, other factors also are important. These include the frequency of interpersonal contact, proximity, complementarity, and reciprocity. Generally speaking, attraction to others increases the more we are exposed to them (frequency), the closer geographically we are to them (proximity), the more their needs appear to complement our own (complementarity), and the more they appear to be attracted to us (reciprocity) (Penrod, 1983).

Friendship

While we know that friends are usually of the same age, race, and sex (Kandel, 1978), we have little information regarding what is involved in friendship formation or termination. Friends characterize each other as persons with whom they share activities, experiences, and interests, who are comfortable to converse with, and who are accepting, dependable, supporting, and understanding. When talking about friendship, men tend to emphasize shared activities and interests, while women emphasize supportiveness (Weiss & Lowenthal, 1975). We might assume, then, that the features friends find important in their relationships are also features that are important in establishing and sustaining those relationships.

The social exchange theory (see Chapter 16), which holds that on some level we weigh the cost-benefit value in deciding to enter into or continue a relationship, offers one way of analyzing friendship. If we feel a relationship costs or will cost more than it is worth, we tend to avoid it. For example, suppose you have a close friend who has begun trying to dominate you or who causes you embarassment. You might feel that the social or emotional costs of the friendship exceeded the benefits, and look for other friends.

Love

Love is a term that is used in a variety of ways to describe various close relationships, and even some things that are not relationships at all. For example, you may love to dance or to fish or to play tennis, or love animals or people. In these usages, to love is merely to have a preference, probably a strong preference.

On another level, we may love our close friends or distant relatives. A still stronger and perhaps somewhat different kind of love is what most of us have for siblings, parents, offspring, or spouses. We can also speak of having various types of bonds with these individuals, and mean the same thing as loving them.

Romantic love is a different sort of bond, in that it involves intense physiological arousal. Romantic love is a type of mating bond, from which a pair bond commonly develops. The old saying "love is blind" often applies to this type of love. We may fail to see the faults of someone to whom we are romantically attached, may imagine that the loved one is better looking or more capable and compatible than is justified. But as Lamberth (1980) says, "No mortal can live up to the fantasized ideal that developed during the passionate state of love" (p. 386).

In many cases the glow of the mating bond lasts until a sound pair bond has been formed. However, our society glorifies romantic love, and tends not to prepare us for its eventual waning. When it fades the lovers may feel they have not been in love after all and may then decide to separate. This may be unfortunate, because it appears that a function of romantic love may be in fact to allow people to overlook minor differences and remain closely associated long enough for a pair bond to be established.

Romantic Relationships

It is surprising that so little information is available about the human behavior that leads to family formation, since that is of such profound significance in the lives of almost everyone.

Results of experiments with computer dating support the results mentioned earlier for attraction. Good looks are number one, and similarity of attitudes is number two in initiating and maintaining romantic relationships. Another result seems to solve the question of whether females should "play hard to get." Apparently a woman is more desirable to a man if she appears hard for *other* men to get, but not for the man she is interested in (Walster, Berscheid, & Walster, 1973).

People who say they are "in love" report they feel dependent on the other, but not insecure. Early feelings of vulnerability are apparently reduced as the relationship progresses and commitment increases, and love and trust seem to fuse (Huston & Levinger, 1978).

What ingredients make for a durable romantic relationship? The evidence suggests what common sense might dictate: (a) similarities in background, interests, goals, and physical attractiveness; and (b) an equitable relationship (Hill, Rubin, & Peplau, 1976; Walster, Walster, & Traupmann, 1978). Although romantic love may be stimulated more by arousal than by anything else, a long term relationship appears to require perceived similarities between partners, and a sense that no one person is doing all or most of the giving or getting. Equity theory was introduced in Chapter 16 as a means of explaining prosocial behavior. This theory also seems ideally suited to illuminating the mechanisms that maintain or destroy a romantic relationship (Walster, Walster, & Berscheid, 1978).

Bonding

A discussion of affiliation leads naturally to an examination of some of the types of close relationships that exist. **Bonding** is involved in close relationships, and one type of bond, the mother-infant bond, is important for the proper formation of all other bonds.

Pair Formation

In many species of freshwater and marine animals no pairing or mating occurs; gametes (eggs and sperm) are merely released into the water, and some enter into fertilization at random. In many other animals mating occurs during a brief encounter; in some of these species the male has a private mating territory, and in many courtship occurs, but no bond is formed.

Chimpanzees are one species in which a *mating bond* usually occurs. A male and female make considerable effort to avoid other chimpanzees and consort together, but only for the days she is in estrus (Wrangham, 1975).

Many species of mammals and birds form a *pair bond* during the breeding season, and cooperate in caring for the young. After the young are old enough to care for themselves the pair breaks up. Many mammals, including some primates, form more permanent pair bonds and raise young together over a period of several years. Human pair bonds are of this last type.

The Mother-Infant Bond

The mother-offspring bond that forms in many species of animals early in life is often attributed to imprinting, discussed in Chapter 8. Some theorists suggest that a "critical period," or "sensitive period," for mother-infant bonding in humans may occur between six and twelve months of age. However, Klaus and Kennel (1976) suggest that mother-infant bonds are formed shortly after birth. Early close contact leads to extended breast feeding, better care, reduced infection, and better weight gain: this finding comes from comparisons between babies who had early close contact with their mothers and premature babies who did not. A larger percentage of premature than of full-term babies do not thrive, although no medical cause can be found. Thus it appears that if mother and infant are separated at the time the bond should be forming between them, it may form imperfectly, or not at all. There may be a biological predisposition on the part of infants to become bonded (Bowlby, 1958). Many behaviors we see in newborns and young infants—for example crying, grasping, rooting, smiling, and visual gaze—may have been preserved by natural selection because they served as signals that elicited parental care. But it is also clear that parental responsiveness to these signals is important in influencing bonding.

Mother-infant bonding may be a prerequisite for the development of other types of bonds.

Studies have shown reliable individual differences in the quality of bonding between children and their parents. Some infants appear to be securely bonded and others anxiously bonded (Ainsworth, 1967). Securely bonded infants do not cling to their mothers incessantly. They apparently feel confident enough to venture out more and explore novel surroundings with their mothers present, but they also seek closeness with their mothers after a period of separation. Anxiously bonded infants show a great deal of distress upon separation from their mothers. They cry more often whether their mothers are present or absent, and they choose to remain close to their mothers rather than explore.

What is most interesting is that different styles of parenting are associated with these two patterns of bonding. Mothers of securely bonded infants appear to be more sensitive to the needs of their babies, especially during feeding, and they generally provide more stimulation than do mothers of anxiously bonded infants. Of course, this evidence is of a correlational nature; we do not know for sure whether the different parenting styles cause the different kinds of bonding or vice versa. Different styles of parenting may be partly due to temperament differences among babies. Some babies are easier to manage than others from the time they are born. The same parent may be rewarded with smiles and laughter for his or her efforts to stimulate an "easy" child, but ignored or punished by a "slow to warm up" child. In this way the parent may *learn* a particular caregiving style because of pleasant or unpleasant encounters with the infant. Of course, another possibility is that different parents respond differently to the signals their infants provide.

The quality of the mother-infant bond seems to have an important bearing on later development. Securely bonded children develop social relations with others more easily, and also exhibit more curiosity. For example, Waters, Wippman, and Sroufe (1979) found that securely bonded eighteen-month-old infants showed more smiling, and more smiling combined with vocalizing and showing of toys, than anxiously bonded infants of the same age. Sharing was greater among securely bonded infants aged eighteen to twenty-four months. And infants that had been judged to be securely bonded at fifteen months showed greater personal and interpersonal abilities in preschool play at age three and a half than did those judged anxiously bonded at fifteen months.

You will recall that in the Harlow experiments with rhesus monkeys, infants isolated from their mothers and all other social contact developed inappropriate social behavior, and females showed poor mothering behavior if they reproduced. Fortunately, similar experiments have not been done with human infants. However, the importance of early bonding to later social development in humans is indicated by comparisons between children growing up in families and those in institutions where there are many caregivers, sometimes as many as eighty.

Anecdotal reports of detrimental effects of institutional child rearing abound. For example, in Russia in the 1920s, shortly after the revolution, infants were often separated from their mothers and placed in a state institution for rearing. According to Vera Schmidt, a psychoanalyst in Russia at the time, there was much higher than normal mortality among these babies. They appeared to suffer from lack of mothering to such a degree that they just "gave up" and died (Edith Buxbaum, personal communication).

More systematic evidence highlights less dramatic, but nonetheless important, behavioral differences between children brought up in families and those reared in institutions. In one study, Tizard and Tizard (1971) found that at two years of age institution-reared children were more clinging and made fewer attachments to others than did family-reared children. At four, institution-reared children showed similar differences, and in addition were more seeking of attention and overly friendly with strangers (Tizard & Rees, 1975).

Less than half of institution-reared children were closely attached to caregivers at age eight, Tizard and Hodges (1978) found, and they sought affection more vigorously. At school, the institution-reared were more attention-seeking, disobedient, restless, and less popular than family-reared children.

These observations on institutionalized children are not meant to imply that the staffs of these institutions were guilty of neglect; they may have done all they could under prevailing conditions. But it is likely that in our evolutionary history, as now, infants were ordinarily attended by their mothers. If the mother died during childbirth, or was otherwise unavailable, maternal care of the infant probably was provided by a close relative, a member of the extended family. (This assumes that anthropologists are correct in their belief that early humans lived in small, closely related bands.)

Experiences in childhood also affect the quality of parenting provided as adults. At least a small percentage of child abusers were themselves abused, neglected, and poorly mothered as children. They may have learned to be aggressive toward their children from witnessing their parents' action and attitudes (Parke & Collmer, 1975). A longitudinal study by Kempe and Kempe (1978) found that parental behavior in the delivery room could predict with fair reliability who would be child abusers later. Those most likely to abuse their children were (1) mothers who did not touch, hold, or explore their babies; (2) mothers who did not vocalize to their babies affectionately; (3) parents who criticized the baby's appearance, did not make eye contact with the baby, seemed disappointed with its sex, or were not affectionate toward one another.

Thus it appears that secure mother-infant bonding is important for later social development, although experience at other ages is undoubtedly important also. It is as though the mother-infant bond functions as a model for the forming of other bonds later, such as friendship, kinship, male-male, and male-female bonds.

Sex-Related Behaviors

This section will focus on differences in certain physical traits, cognitions, and social behaviors between the sexes. Again, the fact that there *are* differences between the sexes does not imply that one is superior or inferior to the other. Also note that many of the behavioral differences mentioned here are *average* differences; the distributions of such behaviors for each sex typically show a great deal of overlap.

A number of differences exist between the sexes in abilities and inclinations. Many of these differences appear to take the same general form in a variety of cultures. Examples would include more strenuous activity and more aggression in males (Hoyenga & Hoyenga, 1984), more nurturance and emotional expressiveness in females (D'Andrade, 1966), and somewhat higher levels of visual-spatial ability in males (Parsons, 1980). There are also sex differences that vary from one culture to another, such as the *extent* to which women are involved in strenuous activities. The remainder of this section is concerned primarily with sex differences that are fairly consistent from culture to culture.

Physical Traits

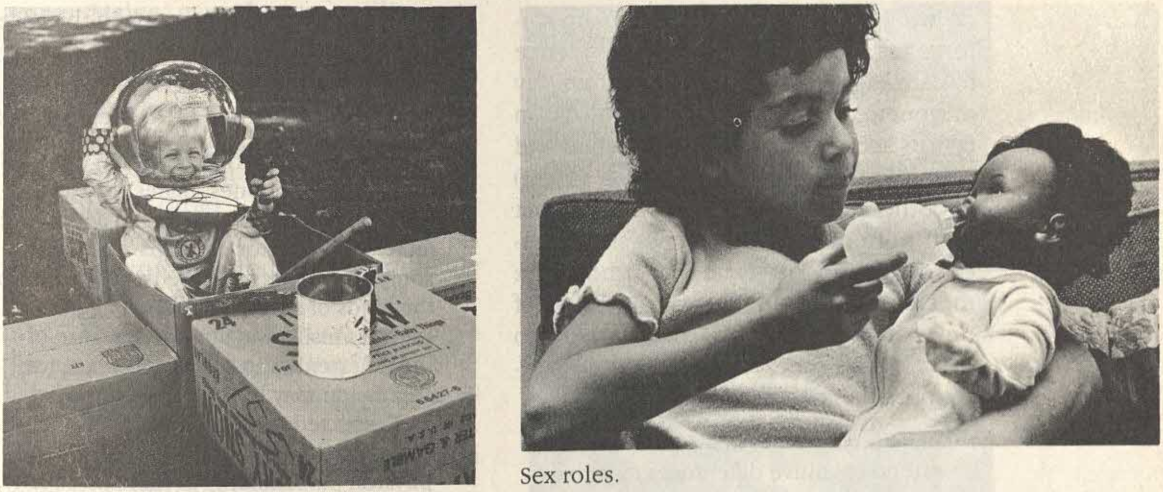
Development of the primary sex characteristics—the sex organs—is influenced by instructions in the genes on the sex chromosomes. In mammals, genetic males (XY) develop testes, and genetic females (XX) develop ovaries, but external male genitalia develop only in response to the properly timed release of androgens by the testes. In humans and other primates the release of androgens occurs prenatally, while in mammals with much shorter periods of immaturity, androgen release occurs postnatally (Benton, 1983). Without the secretion of androgens at the proper time all offspring would develop female genitalia, whether they were genetically male or female.

Secondary sex characteristics (which include differences in muscle mass, fat distribution, and width of shoulders and pelvis) are also controlled by hormones secreted by the sex organs stimulated directly by the pituitary gland, and ultimately by the hypothalamus. The proper timing of these events is also influenced genetically.

Since athletic skills are strongly influenced by muscle mass, it is not surprising that the sexes differ in certain athletic endeavors. For individuals of equal weight, males generally are stronger and quicker in those endeavors that demand such characteristics: the male body is simply more suitable in construction for such activities as sprinting, jumping, lifting, and throwing. However, there is little or no disparity between men and women in events such as long-distance swimming and various acrobatic gymnastics.

The existence of male–female differences in strength and speed is not surprising from an evolutionary perspective. Generally speaking, males in hunter-gatherer groups are, and probably were, more likely to be involved in those aspects of hunting and defense that place a premium on strength and speed. Over a hundred known hunting-gathering societies still exist today, and in nearly all of these, males hunt for large game away from the settlement and provide most of the high-grade protein. Females gather vegetable food, often catch small animals, and provide the most calories. Females also generally prepare the food, make clothing, and build shelters (Wilson, 1978). This is a further division of labor than occurs in most animals. Among other primates males and females each forage for their own food, though sometimes foraging patterns differ. This seems to be the case in chimpanzees, where the occasional hunting that occurs is done mostly by males (Nelson & Jurmain, 1982).

The more striking sexual division of labor in humans may have been favored by natural selection as a result of our ancestors leaving the forests to occupy the savannahs. Scavenging, hunting big game, and constantly defending against predators and competitors would have been required in the relatively hostile savannah habitat. At the same time, the biological realities of childbearing and nursing offspring would have left females with less time and energy than males to devote to hunting and defense. Many of the physical traits necessary for bearing and nurturing the young preclude the development of levels of strength and speed comparable to those possessed by males. Thus, the necessities of hunting and defense on the one hand, and production of biologically successful offspring on the other, may have accentuated sexual division of labor in humans and human ancestors. It is not unreasonable to speculate further that these necessities, and the division of labor, may have operated as selective pressures for certain cognitive and social



Sex roles.

sex differences, as well as differences in the physical traits we have discussed.

Cognitive Processes

Many studies show that human females tend to have better verbal skills than males, while males tend to have better visual-spatial abilities. There is also evidence for slightly better mathematical skills in males, but this seems to be restricted to mathematics requiring spatial visualization, such as geometry. These differences are clearer after adolescence than they are before (Maccoby & Jacklin, 1974; Petersen, 1980).

One interpretation of these findings is that the left brain hemisphere in females is more highly developed than it is in males, and the right hemisphere in males is more highly developed than it is in females. (Recall from Chapter 9 that, for most people, the left hemisphere of the brain seems to be specialized for verbal skills and the right for spatial skills.)

In fact, recent evidence suggests that sex differences in hemispheric functioning along the lines we have discussed may be detected within the first few months of life (Shucard, 1983). However, evidence from brain-damaged patients indicates that there is more to sex differences in brain specialization than a simple opposite hemisphere advantage for each sex. It also appears that there is less specialization overall in females than in males. In other words, in females, *each* hemisphere may be more involved in *both* verbal and spatial skills than is the case in males (Witelson, 1977). Consistent with the idea of less hemispheric specialization in females is evidence showing, for the first time, male-female anatomical differences in the corpus callosum, the body of fibers connecting the two hemispheres. Specifically, females have a strikingly larger posterior portion of the corpus callosum than males (de Lacoste-Utamsing & Holloway, 1982).

There has been considerable controversy over the intrepretation of sex differences in cognition, centering mainly around the nature-nurture issue. Clearly, there appear to be slight structural and functional differences in male and female brains, as we have discussed. However, it is not clear that such differences *cause* sex differences in cognition, nor do we know for sure how the brain differences arise in the first place. Evidence to date suggests that a dynamic interplay of genetic, hormonal, and socialization factors account for both the cerebral and cognitive differences. Petersen (1980) hypothesizes that genetic factors interact with hormones, (androgens, androgen-estrogen ratios, or some other endocrine mechanism) during a critical period of development (prenatal in humans) to produce sex differences in brain organization. She goes on to say

> Brain organization may in turn serve to extend cognitive differences to verbal-versus-spatial skills with the spatial differences then also influencing some math skills. Socialization may serve to make it more likely that boys become good at math and spatial skills (and less likely for girls) while reinforcing verbal . . . skills in girls. The appearance at adolescence of sex differences in these skills may be caused by increased sexually differential socialization at this time and/or by the activational influences of hormones at puberty, perhaps on the termination of brain lateralization (p. 45).

Aggression

By the time social play begins, at about age two or so, males are physically more aggressive than females; this is also true for other male primates. Boys also engage in more hostile fantasy and play fighting, a characteristic that would seem useful for hunting, defending against enemies and predators, and obtaining resources. Aggressiveness is known to be dependent on testosterone level in many animal species, but this has not been established for humans. Maccoby and Jacklin (1974) conclude that a higher level of aggression is more characteristic of males than of females, and could have a genetic origin. But, as we saw in the case of sex differences in cognition, genetic influence may only be part of the story. Hoyenga and Hoyenga (1984) elaborate:

> Because of sex differences in chromosomes and hormones, males may find it easier than females to learn an aggressive motive or behavior. Perhaps males are somewhat more sensitive than females to the kinds of stimuli that elicit aggression (such as insult and attack). Because of the differrences in socialized sex roles, aggression may be more often rewarded and expected in males and may be more often punished (though not with physical punishment) in females. Finally, since (for whatever reason) male adults tend to be more aggressive than female adults in real life as well as in books and on television, most of the models for aggressive behaviors are male. Boys may therefore be more likely than girls to learn to be more aggressive through modeling (p. 302).

Mate Selection

A primary characteristic of all social behavior is a mutual exchange of information. However, information can be misinterpreted or lead to misunderstanding if the characteristics of the sender are different from those of the receiver. This can be the case with human male-female interaction if the parties are not aware of some basic differences between the sexes. Some differences that are not necessarily associated with sexual behavior were presented in the previous section, and here we will examine some differences more clearly related to breeding behavior.

Females of most animal species, including humans, are much more selective in their matings than are males (Daly & Wilson, 1978), and there are adaptive advantages associated with the difference. Males manufacture millions or billions of sperm, and are capable of fertilizing a great number of females. In fact, from the perspective of natural selection and evolution it is to a male's advantage to mate with as many females as possible, in order to get his genes into many different genetic combinations; the more combinations, the more likely some of his offspring will be high in fitness. There is little effect on the male's fitness if some of the matings are unsuccessful in producing young, as long as other matings do result in fit offspring. The production of sperm requires little energy; sperm are cheap.

For females the situation is quite different, because all females invest a great deal of energy in providing for the young. For most animals this involves the production of a large number of eggs, each loaded with energy in the yolk to provide for the young until hatching. In addition, the female may devote a great deal of energy to locating an appropriate site for laying the eggs where the young can find suitable food, and to the egg-laying itself. Also, females of many species reproduce only once (this is the pattern for many insects), or only once a year. So while males may gain by mating with many females and the penalty for choosing an inappropriate mate now and then is small, a female that is not selective may risk her entire reproductive opportunity for that year, and perhaps for her entire life.

In view of the relative investment and risk involved in any one mating, we might predict that natural selection should favor indiscriminate males but highly selective females. In fact, this seems to be what has happened.

Dragonflies in copulation.

For example, male dragonflies will attempt to mate with any female dragonfly, and sometimes even with other males, even though only matings with females of their own species can produce viable offspring. On the other hand, female dragonflies are quite selective in their mating. Females simply refuse to mate except with a male of their own species, and even then they often will not accept the male. Dragonflies are a useful example because among them rape is not possible; males grasp females, but females must actively take the sperm from a special pocket on the male abdomen; therefore it is easy to observe mating if it occurs. If mating is accomplished, the male may stay near the female and guard her during egg-laying, or he may not, depending on species. Either way, the male ultimately leaves to seek another female. Neither a mating bond nor a pair bond is formed.

For dragonflies, as for most insects and many other animals, once eggs are laid the parents take no further interest.

For birds and mammals the situation is quite different. Female birds also produce eggs with much stored energy, and their incubation and protection means additional energy expenditure as well as increased risk. Mammal eggs contain less stored energy, but the young require a great deal of energy from the mother while they are growing. In most birds, and in mammals, the young also must be fed and otherwise cared for after hatching or birth.

Should birds and mammals be similar to dragonflies in the amount of care they devote to mate selection? The answer for females is clearly yes. For males the answer is not as clear. Theoretically, males should be promiscuous in species where they do not help raise the young. In species that form pair bonds the male's help is often essential for successful rearing of the young, but it is still to a male's advantage to mate with other females, because his offspring may be raised with the aid of another male. If so, the promiscuous male's genes will be perpetuated in additional combinations.

Male redwing blackbird displaying from perch on cattail. Many male birds sing from a prominent perch to announce possession of a territory and to attract females.

As long as a pair-bonded male makes a normal contribution to the rearing of the pair's offspring, his mate presumably loses nothing if he is promiscuous. However, the male may lose much or all of his reproductive opportunity if his female mates outside the pair bond, since he may be expending his energies rearing young that carry some other male's genes rather than his own. Thus it is common for males of many species to guard their mates against other males, and there is good evolutionary reason for this. Males who effectively guard their mates normally help rear their own young, while males who do not guard their females risk providing for another male's offspring. It is always clear who the mother is. However, unless the male is with the female 100 percent of the time, he can never be completely certain who the father is. Thus if he is to be sure, he will not have much time for courting and inseminating other females.

Barash's field observations of mountain bluebirds are instructive here (1976). Mountain bluebirds are monogamous, and the male helps incubate the eggs and feed the young. Barash placed stuffed museum specimens of male mountain bluebirds near each of two mountain bluebird nests at times when the female was present and the male was absent, so that when the male returned he found another male near his mate. This was done on three different trials for each nest: during nest building, when copulation would normally be occurring; ten days later, when eggs were in the nest; and after another ten days, when the young had hatched.

On the first trial the returning male

attacked both his mate and the intruding male. At this time female adultery could have resulted in fertilization by the intruding male. One of the nest-building males went so far as to drive his mate away and find another unpaired female with which he raised young. On the second and third trials—after eggs were laid, and after the young had hatched—the returning male attacked only the intruding male, and less vigorously than on the first trial. At these times adultery would have had no effect on the mated male's fitness.

Under what conditions should a male enter into pair-bonding and help rear his young? Wouldn't it be to the male's genetic advantage to expend his energies pursuing and mating with a large number of females and have his genes represented in as many individuals in the next generation as possible? This would be an excellent strategy in species where females copulate only once before laying eggs. For species in which females copulate several times it would seem preferable to form a consort relationship, or mating bond, and wait until eggs are laid, or pregnancy is certain, before searching for another female. In some such species males do this, but in others they do not. Domestic dogs do not, and as a result litters often include offspring fathered by different males. Multiple matings also can be advantageous for females, since in this way their genes are combined with those of several males. Thus from a natural selection standpoint it is of advantage for both sexes to be promiscuous in species where the female can provide all essential parental care.

But such strategies will be successful only if females of the species are capable of providing for the young. If they are not—if females cannot gather sufficient food or provide adequate protection under average conditions—then it will pay off for the male to help care for the offspring, and both sexes will benefit from forming a pair bond.

Male redwing blackbirds establish territorial boundaries, partly by "posing" with beak up at boundary. Males face each other much of the time during boundary establishment. The upper male has just moved from a position facing the lower male, beak up. The lower male moved to face the upper male shortly after the picture was taken.

Therefore, to reply to our earlier question, natural selection dictates that males should form pair bonds with females and invest time and energy in caring for the young when doing so substantially increases the probability of survival of their offspring. Under these conditions both sexes, not just females, should be very selective in choosing who they pair-bond with. A prolonged courtship before mating is the usual means of providing time and opportunity for this evaluation. Both sexes can then assess the suitability of the other as a parent—as an individual with suitable characteristics, capable of producing successful members of the next generation. Once the female has laid eggs or is pregnant, it is again to the male's evolutionary advantage to attempt to inseminate other females, providing he does not neglect his major investment—the female he is bonded to, and his offspring.

Much as it may offend our moral values, it is apparent that human behavior tends in this direction. Males generally are much more easily aroused sexually and are more willing to copulate than females are. Both sexes are following reproductive strategies that are based on (although not controlled by) their genetic constitutions. It is striking how similar the behavior of the human sexes are in this respect to those of animals. In both animals and humans, males and females operate with somewhat different sets of values. Males tend to place a higher value on copulation itself, while females tend to place a higher value on the qualities of the male with whom they copulate (Wilson, 1978). This is not to say that it *should* be this way, nor that it is good, but simply that it seems to be. Also, it should be emphasized that not *all* males or females respond this way.

Resources and Resource Control

Males of many species of mammals and birds establish territories. In an ecological context a territory is an area containing resources that is defended against competitors. There are several types of territories, but the type that is most important for this discussion is established before the breeding season and before the arrival of females. A male arrives at the breeding area and threatens or fights with other males to establish a territory, which is then used to attract a female and provide a nesting site and food for the pair and their young. We also know that a female's choice of a male is generally based on the quality of the territory, and therefore the resources, that he controls.

The quality of the territory ("the real estate," as many ecologists are fond of saying) is a means of judging the quality of the male. Resources are essential for rearing a family—for passing genes to the next generation. Ecologists assume that a male controlling high-quality resources has the "high-quality" genes necessary for controlling those resources, and will pass those genes on to his offspring. In mountain bluebirds and many other species, the suitability of a male to be the father of offspring is assessed by the female at least partly on the basis of the quality of the resources he controls.

Human territories are usually much larger and more complex than those of other species of mammals and birds, but it seems clear that humans evolved as a territorial species, with territory functioning to control resources, as it does in other animals (Wilson, 1975). Thus it is reasonable to speculate that human females also may base part of their evaluation of a potential mate on the adequacy of his "territory"—the resources he can control.

Mates as Resources. We have described resources as features of the environment that contribute to fitness. Since fitness involves survival and reproduction, it is apparent that mates can be viewed as resources.

Among our ancestors, as among living aboriginal peoples, females needed protein, protection, sex, and children, and males were the environmental resource that provided these. Males needed sex, vegetable food, food preparation, and children, and females were the source of these.

Females are not only a resource, but a limited resource. One male can fertilize a large number of females, but due to the long human gestation period, production of offspring by any one female is limited. Thus females became a focus of competition among males. In aboriginal groups males need sons to help in the hunt or other food production, and daughters to exchange with other groups. Females need offspring to help with such activities as gathering food and assisting in the care of younger siblings, and both sexes need children if their genes are to be represented in future generations.

Females can be a resource in a broader sense as well. In virtually all aboriginal societies exchange of females takes place. Individuals from one clan or family group marry outside the group, and most often the female goes to live with the male. An exchange of females is used to form political and economic alliances; through marriage, groups become related, genetically as well as socially. This aspect of marriage is still sometimes in evidence. For example, in industrial societies today wealthy families tend to send their offspring to the same schools and, through their marriages, form alliances. And for most of us it is common to give relatives favorable treatment, just as it is uncommon to give them unfavorable treatment.

Historically, marriage has been a means of establishing control over resources, including mates and offspring. Many marriage ceremonies still instruct females to obey the male, and many parents encourage their daughters to select more prestigous, older, and economically secure males — "good providers" — as marriage partners.

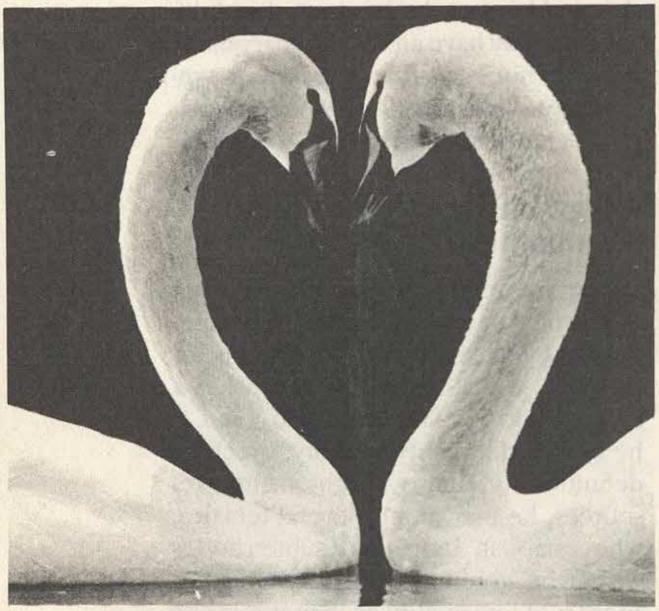
Let us make it clear that we are *not* advocating male domination of females, or treatment of either females or males simply as resources. Although sexual division of labor and other sex-related differences may have an evolutionary basis, this does not mean that sexual stereotyping or sex discrimination in modern societies is justified or should be tolerated.

Polygynous and Monogamous Relationships

Polygyny refers to one male having more than one female mate at a time. Redwing blackbirds are polygynous, or try to be. A male redwing establishes a territory and waits for females to come. If he has a high-quality territory, which by definition contains high-quality resources, he may attract several females, who establish individual subterritories within the larger male territory. If the territory is of low quality he may attract one female, or none. We mentioned earlier that females of territorial species choose the "real estate" and accept its "owner" as a mate. But why should a female choose to mate with a male who is already mated? Or better, under what conditions should she so choose? The answer is: when she stands a better chance of producing a normal number of successful offspring. Field studies confirm this. Several females mated to a male with a high-quality territory fledge more offspring per female than do those in single-female territories (Orians, 1980b). In the case of redwing blackbirds, and in many other species, polygyny seems to be adaptive.

Polygynous relationships are most common in mammals and monogamous relationships are most common in birds, the redwing blackbird notwithstanding. Why is this so? Barash (1977) explains:

> Because of the high metabolic rate and consequent food needs of developing nestlings, the cooperation of two parents may well enhance the survival and



Most species of birds are monogamous, and several maintain a mating bond for life, or at least for several years, even at times other than the breeding season. The mating bonds of swans are of this type.

> ultimate success of the young, which in turn increases the fitness of the parents. Monogamy may be adaptive for these species, because it ensures a greater food supply for the young. This is supported by the observation that, among monogamously mated species, generally both parents share in provisioning their offspring and that a single parent is often unable to provide as much food as a mated pair . . . , resulting in lower reproductive success. This evaluation is further enhanced by the observations that amongst most polygamous and promiscuous birds, species in which one parent typically cares for the offspring, food is either present in great abundance, e.g., marsh-nesting species such as redwing blackbirds, so that a single parent can forage adequately for its brood, or the young are relatively precocious at hatching and can forage for themselves, e.g., pheasants and grouse (pp. 55–56).

For mammals, Barash continues, the situation is different:

> Because female mammals are uniquely adapted to nourish their young with milk, males are limited in terms of how they can increase their fitness through direct interaction with their offspring. . . . As predicted . . . monogamy is accordingly rare among mammals, especially among herbivores [plant eaters] . . . in which the low caloric value of their food makes provisioning by the male especially inefficient (pp. 161–62).

A majority of human societies permit polygyny, and many encourage it through laws (Wilson, 1978). In some of these societies individuals have no say in the choice of a mate, but in others they do. From an evolutionary perspective, under what conditions would it benefit a female to voluntarily enter into a polygynous relationship? The answer: when it increases her fitness — when the probability of her survival and reproductive success are greater than in a monogamous arrangement. Consider societies in which there are two classes, the very rich and the very poor. One of *several* wives of a very rich man can live in comfort and produce healthy, well-fed offspring, who in turn have a much better opportunity for a pleasant life. The prospects for the *single* wife of a man living in poverty, and for her children, are quite different. The harems of some Middle Eastern cultures, in which one man may have several hundred wives, are extreme examples.

Most monogamous societies are kept that way by strict laws. Even so, many are in practice polygynous, in that extramarital relationships occur. Sometimes they are allowed, or even expected.

Incest

The mating of close relatives, called **incest**, is repulsive to most people. It is also illegal. Why should this be so? Certainly we have a better opportunity to evaluate the suitability of others as mates if we are closely associated with them, and particularly if we grow up with them.

Nevertheless, incest taboos are almost universal in human societies. Surely people must have observed, long before our knowledge of genetics, that closely related individuals were more likely to produce mentally or physically deficient offspring than were more distantly related couples. We now know that all individuals carry some harmful genes, but their effects are usually not expressed because they are mostly recessive. However, siblings have half their genes in common, and there is a relatively high probability that a child from such a mating may "show" an undesirable characteristic.

For example, if recessive gene *a* influences a characteristic in an undesirable way, while its dominant allele *A* influences a trait in a normal, desirable way, and if two siblings are both normal but *Aa* with respect to this trait, the chances are one in four that their child would be *aa* and would have the undesirable characteristic. Another family may not carry *a* but instead carry undesirable recessive gene *b*, with some individuals being *Bb*. If members of the two families marry, one may be *AaBB* and the other *AABb*, but none of their children can end up with either *aa* or *bb*, so the undesirable trait does not appear. In this way incest taboos are supported by genetic reality.

It is interesting that most individuals have no desire to marry others with whom they grew up—siblings, cousins, or even nonrelatives. The kibbutz experience is informative here. In Israel male and female children were raised together in kibbutzim with the hope that they would ultimately marry within the kibbutz. Boys and girls were free to sleep in the same room, but as they grew up most came to prefer living in all-male or all-female rooms, and there were no known instances of heterosexual activity. A study of the kibbutz experience showed that of 2,769 marriages of individuals who had grown up in a kibbutz, none were between members of the same peer group who had grown up together (Shepher, 1971).

Why do we have these preferences? It is possible that natural selection may have favored the offspring of those who were not inclined to mate with individuals they grew up with, who would normally be close relatives.

18

Communication and Language

Origins of Signals

Characterizing Language

The Biological Basis of Language

The Evolution of Language

The Development of Language

Language and Thought

Chapter Preview

Communication involves a transfer of information from one individual to another through tactual, chemical, auditory, and visual signals. The most obvious form of communication among humans is *language,* a system of symbols and meanings that is organized according to rules and is used in communication. Language differs from other kinds of communication in the *symbols* used, the *rules* that govern their use, and especially, the *creativity* that characterizes symbol usage. Language symbols are arbitrary with respect to the meanings they convey, rather than universal and fixed, as in other forms of communication. Language rules are more numerous, complex, and abstract than in other kinds of communication. Finally, language is open-ended and flexible, so that speakers can understand or produce any number of novel and meaningful word combinations. This element of creativity is not characteristic of nonlinguistic forms of communication.

Humans appear to be biologically adapted for extremely flexible vocal communication. Anatomical features of the mouth, teeth, tongue, larynx, and brain are especially conducive to the production of a wide variety of vocal sounds. The acquisition of language follows an orderly sequence that is the same regardless of the language spoken, and is tied closely to the maturation of motor skills in infants and young children. There is also evidence for a sensitive period for language acquisition. Finally, while experience is important for language acquisition, very little experience is necessary for the emergence of language.

Why did language evolve, and when and how did it make its first appearance? Answers to such questions are speculative, but several pieces of evidence provide clues. It is thought that language must have facilitated the hunter-gatherer way of life, especially the social organization and cohesion that are so important to the success of such groups.

The capacity for primitive language, or at least a highly flexible system of vocal communication, may go back as far as our early human or even prehuman ancestors. Fossil evidence suggests the possibility of brain specialization related to language as early as two million years ago.

Given what we know about brain specialization for speech and its apparent long history in hominids, it seems reasonable to speculate that language originated from more primitive vocal utterances. With increases in hominid brain size and organization and changes in vocal anatomy came ever-increasing flexibility in the production of vocalizations. When hominids began to *combine* sounds, an impetus would have been provided for a quantum leap in the evolution of language and in brain size and organization.

Newborns are capable of perceiving and producing a variety of speech sounds. By the end of the first year many children begin speaking their first words. Two-word sentences are produced beginning around eighteen months of age, and gradually elaborated in richness and meaning. By the age of four or five children have acquired most of the basic rules of their native language.

Probably classical conditioning, instrumental learning, and observational learning all play important roles in language acquisition. However, some theorists hold that language is so complex, yet acquired so rapidly, that a biological readiness for learning language seems likely.

Does language *determine* our cognitions, or does it simply reflect the way we think? The hypothesis that all forms of human thought depend upon language is not supported by research. However, it does appear that language can facilitate thinking and problem-solving in various ways.

Communication involves a transfer of information from one individual to another through signals; one individual produces a signal and another receives it. If a signal is not received, there is no communication. If a signal is misinterpreted or not interpreted by the receiver, there is a failure of communication: either the information transferred is faulty or communication does not occur.

Evolution theory would predict that a signal should benefit the signaler. To do so the signal must convey accurate information to the receiver. The receiver ordinarily must benefit also, otherwise it would not be worth while for the receiver to process the signal. The benefit to the receiver need be no more than perceiving the information provided by the signal — information that allows the receiver to know something about the sender, such as what the sender is doing or intends to do. Having this information may allow the receiver to alter behavior in such a way as to improve fitness.

There are four major types of signals detected by the receiver: tactual, chemical, auditory, and visual. *Tactual* signals would seem to be the most primitive, in that they require the least sophisticated receptors. Certainly humans and other animals convey information regarding location, and perhaps even intimacy, by touch. However, it is often useful to be able to transmit and detect information at some distance, so we might consider tactual communication to be generally less useful than the other types. Certainly it is the least discussed, and perhaps the least used.

Chemical communication is important in a large number of species, and may be the most widespread type of communication. For example, slime molds are primitive amoeba-like fungi that aggregate and form fruiting structures in response to pheromones. Many marine invertebrates release gametes into the water only after detecting the chemical "message" that another individual of the species is nearby and prepared to release gametes. And the chemical signals emitted by ovulating female mammals, including primates other than humans, are well known, especially to the owners of female dogs who find all the male dogs in the neighborhood congregating on the front lawn.

The sense of smell is more acute in human females during ovulation, and we might assume this had some unknown function in our ancestors. It is possible that one or more pheromones associated with human perspiration contribute to the synchronizing of menstrual cycles sometimes found among women living together (Hassett, 1978). There is even evidence suggesting that certain chemicals normally present in vaginal secretions may influence the frequency of sexual activity in married couples (Morris & Udry, 1978). These chemicals, known as **copulins,** are especially abundant during ovulation. The possible communicative and adaptive significance of copulins should be obvious.

The most apparent use of olfaction in humans is in connection with food. We may respond with a feeling of hunger when we detect the aroma of our favorite foods cooking, and we use the odor produced by bacterial metabolism as a signal that food has spoiled.

But chemical signals are also limited in their usefulness. The difficulty in locating their source, compared with the ease of locating the source of other types of signals, and the lack of variety of information any one chemical signal can carry, limit their utility.

Auditory and *visual* signals are familiar to us because we use them constantly. Hearing is our major means of receiving communication from other humans, and it is important for gaining a great deal of other information about our environment. But vision provides us with the majority of our environmental information, and is highly useful in communicating with other humans as well. Evaluating gestures, facial expressions, and body movements can be useful and even critical in gaining a full understanding of another's intended meaning, and sometimes in detecting feelings or intentions the other person did not intend to communicate. Maybe you have written a letter or had a telephone conversation in which your intended meaning was misinterpreted. Or perhaps you have found another person hard to believe or hard to trust, for no other reason than the way the other person "came across"; something about that person made you wary. Either

In the left photo above a !Ko Bushwoman is kissing an infant, then in the right photo above, is offering some food by pushing it toward the child's open mouth. In the photo at right a !Ko Bushwoman holds two babies while kissing one of them. Obviously, the communicative signals involved here are multimodal — probably involving touch, smell, taste, vision, and perhaps audition.

of these experiences shows that there is much more to human communication than the words we use.

Origins of Signals

We don't know how the use of any signals originated in any group of animals, but we can make some guesses. It is likely that many signals were initially by-products of normal day-to-day activities. For example, many animals, from bobcats to squirrels, mark territory boundaries with feces or urine. These natural bodily wastes contain substances that produce odors detectable by other individuals. If they are deposited in places where they can be easily noticed, they can serve as signals to others. These odors function somewhat similarly to bird songs, not only announcing that the territory is occupied, but allowing identification of the individual that produced the scent mark and giving some indication of how recently the "signal" was deposited.

In humans, normal body movements that usually precede certain behaviors are useful both in expressing and detecting the intentions of the performer. A clenched fist, an extended open hand, a movement of the body in the direction one intends to go are all well-known examples of what are called *intention movements.* Other gestures are also useful in indicating location or describing shape. For example, try describing a spiral staircase with and without the use of gestures.

It also seems obvious that vocalizations must have been used as signals as soon as the capacity to produce them developed. It is highly unlikely that the capacity to produce vocalizations would have been retained, much less improved to the complexity now found in birds and humans, if vocalizations had not in some way increased the fitness of the vocalizer.

Just as there are universal cultural practices, there are universal signals among humans. Smiling and laughing are everywhere expressions of joy and happiness, or sometimes embarrassment; both pain and sadness are expressed by similar utterances and facial expressions in different cultures; bowing is a universal signal of submission. Cross-cultural consistencies in the use and interpretation of various facial expressions are, in fact, well known (Ekman & Friesen, 1971). Even blind and blind-and-deaf children commonly shake the head as a negative signal, and smile when pleased. An excellent review of various facial expressions and movements is given by Eibl-Eibesfeldt (1975).

Characterizing Language

Language is a system of symbols and meanings, organized according to rules, that is used in communication. Language is not the same thing as communication; rather, it is a type of communication, the most complex and flexible system known. Major features that differentiate language from other forms of communication include the nature of the symbols used, the rules that govern their use, and the creativity that characterizes symbol usage.

Symbols

Many nonlinguistic communicative symbols are *iconic*; that is to say, the nature of the signal itself tells us something about the intended message. Certain obscene gestures by their very nature communicate sexual or sexual-aggressive intentions. Many other nonlinguistic signals reliably elicit specific responses on the part of the observer, responses that often appear to have an innate basis. The baring of teeth in a wolf and the "begging" response of a newly hatched bird are examples of such communicative signals. The bared teeth usually elicit submissive or fighting behavior in other wolves. Whatever the result, the aggressive intent of this signal is clear to other wolves, and to members of some other species. The begging response in newly hatched birds typically elicits feeding behavior from the parent. The connection between such signals and their meanings is fixed and universal within a species. On the other hand, *linguistic* symbols usually are quite flexible—that is, they are ***arbitrary*** with respect to the meanings they convey. This is most easily seen in the fact that different groups of humans use different words and word combinations to mean the same thing. Essentially *any* word can be assigned a particular meaning, as long as the group agrees to this. This is far different from the fixed and universal nature of iconic and innately based communication signals.

Rules

Linguistic communication also differs from other kinds of communication in that it is highly structured and organized according to very specific rules. Language is much more than a mental dictionary of words and word meanings. The heart of language is the rules that govern its use. Words are not strung together randomly; for speech to be intelligible, words must be combined according to the underlying rules of grammar that are shaped by speakers of the same language.

Chased dog the cat represents a string of words whose meaning is ambiguous because it is not formed according to grammatical rules. A listener may know the meaning of each word, but it is impossible to decipher the meaning from this ungrammatical combination. Linguistic rules involving *word order* are among the most powerful for conveying meaning. In English, most grammatical sentences consist of the subject (actual or implied) first, followed by the verb and then the object. The subject-verb-object (SVO) order is the preferred order not only in English but in many other languages as well. In fact, linguists have found that SVO and SOV are the preferred orders in the majority of languages that have been studied. VSO and VOS are much less common, and no language is known in which OVS or OSV are preferred orders. Note that all six orders do occur, sometimes within the same language (Russian, for example). However, some orders occur more frequently than others. For example, even though all six orders can be used in forming simple sentences in Russian, SVO is probably the most frequent (Dale, 1976). Languages also differ with respect to how much they rely on word order to convey meaning. In Latin, the words of a sentence may be placed in nearly any order. But Latin, and other languages that are less constrained by word order, have other ways of conveying meaning, such as a greater reliance on the use of inflections — changes in word form marking changes in tense, number, gender, or whatever (as in *work, worked, working*).

It is important to understand that rules are a defining feature of language and can be complex and abstract. In view of their complexity it is rather amazing that virtually all people master at least the basic rules. What is even more intriguing is that most people cannot identify the linguistic rules they are using, yet are quite capable of producing and understanding intelligible speech, even if it may not be perfectly grammatical. This may seem strange, but consider the following analogy:

> Imagine tying your shoelaces. Now try to explain exactly how you do it. To keep the game honest, clasp your hands together in front of you, so that you cannot simply demonstrate the action. It is all but impossible to explain the process.
>
> Language has this elusive I-can-do-it-but-I-cannot-tell-you-how property. As human beings, we spend a large proportion of our time engaged in speaking or listening, but the process is usually so effortless that we are unaware of how to do it (Dale, 1976, p. 62).

Creativity

Language is creative. What this means is that language is open-ended — speakers of a language can understand or produce any number of novel but meaningful word combinations. Stated another way, humans who have acquired the rules of language can talk about almost anything they please. As far as we know, this kind of flexibility is not present in nonlinguistic communication. Nonhuman communicative signals are usually fixed in number and convey a limited number of meanings. For many species such signals seem to be restricted to situations involving defense against predators or competitors, advertisement of territories, feeding, and sexual behavior. Nonhuman primates and aquatic mammals such as dolphins and whales have extensive "vocabularies," compared to most other species, but appear to lack the quality of creativity in their communications.

It may be that creativity is the feature that best differentiates human language from other kinds of communication. It is possible to find a certain amount of arbitrariness in symbols and to infer underlying rules in the communication of some nonhuman species. But the open-endedness of language is rarely, if ever, found in the natural communicative behavior of nonhuman species.

The Biological Basis of Language

Humans appear to be biologically adapted for extremely flexible vocal communication. And many experts on language argue that the readiness to acquire the rules of language, and perhaps even some of the rules themselves, have an innate basis. But even if we did not string words together according to rules in a creative fashion, humans still would probably have the richest and most flexible *nonlinguistic* vocal communication system of any living species. The reasons for this lie in the anatomical structure and function of our vocal apparatus and nervous system (Aitchison, 1976).

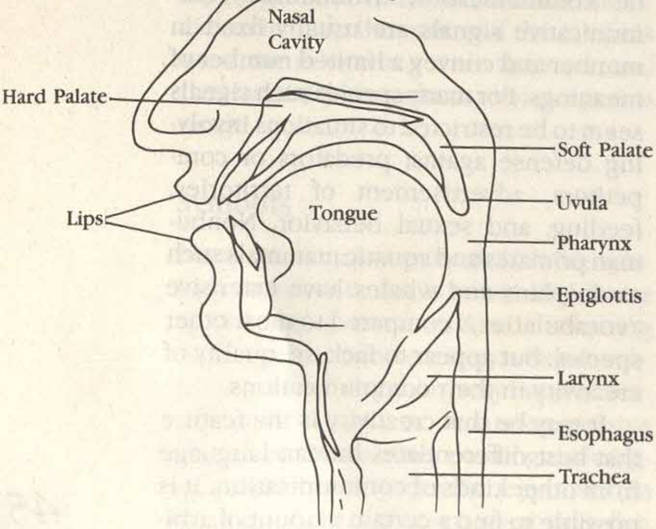
Vocal and Nervous System Adaptations

Compared to those of other animals, human teeth are quite distinctive. They tend to be upright and of the same height, and form an unbroken barrier. This regularity is not essential for eating, but is necessary for articulating various sounds. The human mouth is small, and the lips have muscles that permit a great deal more flexibility than is found in other primates. The tongue is thicker, shorter, and more mobile than that of other primates, which allows flexible variation in the effective size of the mouth cavity, permitting production of a wide variety of sounds. In addition, the molar rows diverge front to back, and the hard palate is more highly arched than in other primates, allowing more space for the tongue to move (Figure 18.1).

The human larynx contains the vocal cords. Because it is simpler in structure than in other primates, it allows air to be expelled through the nose and mouth without interference from other structures. This streamlining of the larynx contributes to the clear, resonating, and distinct sounds that characterize human vocalization.

Humans have a higher brain-to-body-weight ratio than other primates, and perhaps our larger brain makes possible the complex and flexible neurological processing necessary to support language. However, the human brain appears to differ qualitatively, not just quantitatively, from that of our primate relatives. Our brains seem to be specially

Figure 18.1 The human vocal tract, the anatomy of which seems especially well suited to the production of a wide variety of sounds.



"wired" for decoding and producing speech. In Chapter 9 we discussed the specialization of function of the two hemispheres of the brain. This specialization, called **lateralization,** increases during childhood and appears to be complete by adolescence or perhaps much earlier (Reynolds & Flagg, 1983).

The left hemisphere controls language in approximately 98 percent of right-handed individuals and in about two-thirds of left-handers. In many cases, damage to the left hemisphere of the brain produces **aphasias,** speech disorders that can be permanent. Similar damage to the right hemisphere does not seem to affect speech adversely, although it may well interfere with other functions.

The areas of the brain that are responsible for comprehension and production of speech are separate from each other, but are connected by a bundle of nerve fibers called the *arcuate fasciculus.* Speech comprehension appears to be the primary function of **Wernicke's area,** located in the posterior portion of the hemisphere responsible for language, under the ear. Speech production is regulated by **Broca's area,** located in the interior portion of the hemisphere responsible for language, in front of and just above the ear.

Damage to Wernicke's area as the result of a stroke or other trauma often results in a failure to understand spoken or written language, and although speech can be produced, it is typically unintelligible. Damage to Broca's area results in speech that is slow and poorly articulated, although it is grammatical and meaningful. These areas, which constitute what is called the language cortex, have been found to be larger in the left hemisphere of most people than corresponding areas in the right hemisphere. Thus there seems to be an anatomical asymmetry in the human brain that is very much related to language. It has been found in the brains of infants, and there is fossil evidence of asymmetry in *Homo erectus,* suggesting that the capability for language existed as early as two or three hundred thousand years ago in the hominid line.

Biological Readiness for Language

From the evidence presented, it seems fairly clear that humans are anatomically specialized for language. But other, more indirect evidence also points to a biological basis for language. This evidence concerns the way children acquire their native language.

For all of the languages that have been studied, patterns of language acquisition show remarkable uniformity. The same basic speech sounds are made by infants around the world, regardless of the language that is spoken by the child's parents. The timing of this occurrence is also quite uniform in all language groups, taking place within the first two to three months of life. In addition, the developmental course of language acquisition during infancy and the preschool years varies little from one linguistic environment to another. Children around the world usually utter their first words shortly after their first birthday, are forming two-word combinations at approximately eighteen to twenty-four months of age, and by four or five years have acquired the basic rules of language. In most children these major language milestones correlate with major motor milestones. The change from cooing (mainly vowel sounds) to babbling (speech-like consonant-vowel combinations) occurs at about the time an infant begins to sit up, at approximately six

Sitting up unsupported is an example of a developmental motor milestone that correlates with changes in prelinguistic vocal behavior.

months of age. Single-word utterances usually occur just before the onset of walking, and increasing complexity of language parallels increasing levels of physical-motor coordination.

Given the diversity of culture in the world, the observed cross-cultural uniformity in language acquisition is consistent with the hypothesis that many language milestones occur regardless of fluctuations in the external environment, in accordance with a maturational timetable. If the developmental course of language were extremely sensitive to the environment, we would expect to see much greater cultural variation in the content and timing of language acquisition. But instead we see language unfold in a manner that resembles, and corresponds with, the maturation of physical structures and motor skills.

A Sensitive Period for Language Acquisition

A sensitive period for development implies a time when a rapidly developing structure or behavior is especially vulnerable to inputs from the environment. In some cases the presence of certain environmental agents will interfere with development during a sensitive period. In others the *absence* of certain environmental conditions during a sensitive period will result in aberrant development. It appears that the timing of sensitive periods is often influenced genetically, to produce development or learning that is important to survival.

There is reason to suspect a sensitive period for language acquisition, although its duration and significance are matters of debate. Lenneberg (1969) proposed that the sensitive period lasts from approximately two years until adolescence. According to this hypothesis, a child not exposed to language prior to adolescence is not likely to acquire it thereafter.

The evidence pointing to a sensitive period for language is indirect but fairly consistent. First, there are instances in which children have been deprived of exposure to spoken language. This can happen in cases of congenital deafness, and in cases of children isolated from human social stimulation for an extended period of time. Despite the severity of these instances of deprivation remarkable gains can be made in teaching language to such children, but usually only if teaching is begun before the child reaches puberty.

Additional evidence regarding the sensitive period hypothesis comes from observations of certain groups of retarded children. Generally, such children make slower progress in language acquisition than their nonretarded peers of equivalent chronological age. However, their language typically ceases to improve once they have reached puberty. As Lenneberg (1969) puts it:

> If the child's mental developmental age is 2 when he is 4 years old (that is, his I.Q. is 50), one may safely predict that some small progress will be made in language development. He will slowly move through the usual stages of infant language, although the rate of development will gradually slow down. In virtually all of these cases, language development comes to a complete standstill in the early teens, so that these individuals are arrested in primitive stages of language development that are perpetuated for the rest of their lives. Training and motivation are of little help (p. 640).

Our knowledge of the developing brain is consistent with the sensitive period hypothesis. Although in the majority of adults the left hemisphere is primarily responsible for the control of language functions, this degree of specialization is not apparent in young children. However, there is some controversy over just how specialized the brains of young children are (Kinsbourne & Smith, 1974), and some studies indicate the possibility of sex differences in the degree of specialization present during childhood (Witelson, 1976, 1977). Nevertheless, left-right polarization of brain functions appears to increase with development during childhood. Supporting evidence comes from a variety of sources, but the most dramatic illustrations are clinical observations of individuals who have sustained injury to the brain. Injury to the left hemisphere in adults usually results in aphasias, often permanent. Injury to the right hemisphere typically does not lead to speech impairments. But the picture is quite different if comparable injuries occur during childhood:

> Lesions of the left hemisphere in children under age 2 are no more injurious to future language development than are lesions of the right hemisphere. Children whose brain is traumatized after the onset of language but before the age of 4 usually have transient aphasias; language is quickly re-established, however, if the right hemisphere remains intact. Often these children regain language by going through stages of language development similar to those of the 2-year-old, but they traverse each stage at greater speed. Lesions incurred before the very early teens also carry an excellent prognosis, permanent residues of symptoms being extremely rare (Lenneberg, 1969, p. 639).

These clinical observations suggest that there is increasing language-related specialization in the brain during childhood, and they provide a clue as to why a sensitive period for language learning should end. In the case of a language-deprived child, once the brain has matured and become specialized the areas that normally *could* have assumed control over language functions may have become involved in controlling other activities and thus are no longer available to develop a "support system" for language. Presumably it is much easier to acquire language when the brain is relatively open to linguistic inputs.

It must be emphasized that the apparent sensitive period associated with language acquisition may not relate to language directly. The sensitive period could be tied to the development of certain analytical cognitive skills that are required for learning the rules of language.

Language and Experience

Some experience with language during childhood is important, if not crucial for the acquisition of language. Moreover, children who experience different linguistic environments begin to show different characteristic patterns of speech even as infants. Analyses of sound spectrograms show that the babbling of Japanese infants six to eight months old differs from that of American infants the same age, and the sounds made by infants born and raised in America differ from those of infants born in America and raised in Argentina (Hofer, 1981).

Clearly, different linguistic experiences produce subtle differences in vocalization, even at a very early age. Yet it is surprising how *little* experience or training is necessary for children to acquire language. Few parents worry about formulating a curriculum for teaching language to their year-old child. This kind of learning is remarkably natural to children, and they actively seek it out. In fact, even though parents may repeat and *expand* on their young children's sentences by grammatically enriching them, it is not clear that such behavior is necessary *or* sufficient for children to progress to more advanced linguistic accomplishments (Gardner, 1982). And, you may be surprised to find out that longitudinal data indicate that parents tend to reinforce the factual accuracy of their children's sentences more often than they reinforce grammatical correctness. Yet children do achieve some measure of grammatical accuracy in spite of their parents' reward patterns (Brown, Cazden, & Bellugi, 1969).

The sentences of young children do not always follow the speech models they have been exposed to. Children are notorious for producing novel, and sometimes bizarre, word combinations that they have never heard anyone else use, but that convey meaning—for example, "all-gone Daddy?" or "Mommy go car." But of course children's speech improves with experience.

Children are highly motivated to learn language, even in the face of deprivation of linguistic experience. Feldman, Goldin-Meadow, and Gleitman (1978) studied six children who were born deaf and had not been instructed in sign language. Their findings were surprising, and impressive. The parents of these children had decided not to instruct their children in sign language, but rather to teach them lip-reading. The deaf children were loved and were not socially deprived, but they were exposed to no sign language. Before the children had any knowledge of spoken English, they were observed to begin signing manually in a *spontaneous* fashion. The children began by simply pointing to objects in their environment. Then they began to invent their own signs to refer to objects and actions. There was even evidence of spontaneous *combinations* of these signs into primitive sentences. This achievement occurred about the same time that normal hearing children start forming sentences. Goldin-Meadow and Mylander (1983) have also reported the beginnings of a gestural language in deaf children not exposed to a conventional manual language. These findings suggest not only a biological ability to learn language, but also a strong biological *motivation* to do so.

The Evolution of Language

Why did spoken language evolve in humans? We can only speculate based upon the ecological forces with which our hominid ancestors had to contend, and upon what we know about the functions of language. Our early human ancestors depended increasingly on meat for food, and this undoubtedly led to a corresponding increase in investment of time and energy devoted to hunting.

From our knowledge of hunter-gatherer groups still in existence, it is clear that such activities require an organized and social way of life. When hunting, men organize into small groups to converge on prey, and the women remain at a distant location where they can gather plants, roots, berries, and so on. The groups reunite at the day's end to share the fruits of their labor. All of this requires planning and coordinated efforts.

Imagine the tremendous advantages that language would bestow upon individuals in hunter-gatherer groups. As long as the individuals remained fairly close together, gestural or nonlinguistic vocal communication would probably serve them quite well. But nonlinguistic communication is, for the most part, restricted to the here and now. Without language, individuals or groups must never get out of shouting distance from one another, and are limited to immediate sights, sounds, and smells as sources of information about whether to approach or avoid a particular situation.

Language, on the other hand, allows communication about the future. Because of this feature, language would make possible the construction and communication of detailed strategies and contingency plans in preparation for hunting and gathering sorties. Language also provides a code well suited for remembering and communicating temporal sequences of events. Moreover, landmarks and their spatial locations can be designated by words and integrated within a temporal sequence. So language would make it possible for one member of a hunting party to reconnoiter an area and communicate details about the landmarks and events that had been encountered, as well as the temporal sequence in which they had been encountered. Experienced hunters could communicate probable locations of prey, predators, sources of water and shelter, and geographical barriers such as swamps or mountain ranges. The ability of listeners to form images from the words spoken by the returning scout or by the wise old hunters, and their ability to preserve the meanings of those words in long-term memory, would eliminate the need for firsthand experience. In fact, this information could be transmitted from one group to another or from one generation to another. This is perhaps one of the most important advantages of language: it enables individuals to learn and profit from the experiences of others, allowing relatively low risk and investment of energy and a higher likelihood of success in attempting to survive.

Language, in the form of storytelling here, can provide a means of improving social awareness and cohesion in hunter–gatherer groups.

It seems reasonable to argue that the capacity to generate a wide variety of meaningful sounds, to connect these sounds into primitive sentences, and to use these sounds as a means to remember and elicit images in others would have given hunter-gatherers who possessed such abilities a survival advantage over those limited to nonlinguistic communication. Those with the capacity for langauge could afford to hunt and explore over a larger terrain and in a more calculated and efficient manner.

But language may also have had advantages for aspects of life not encompassed directly by hunting and gathering. As we mentioned before, a hunting-and-gathering existence involves an organized and highly social way of living. Organization is greatly enhanced by the construction of rules, taboos, and sanctions. Social stresses and tensions may be reduced, and social cohesion promoted, by the sharing of thoughts and feelings among members of a group, either on an interpersonal basis or by means of group rituals. Kinship systems, so important in establishing cultural roles, mobilizing people and resources, and circulating potential mates within the population, can be formalized. Obviously, language provides a means for accomplishing these things.

Some students of human evolution argue that language, or at least a rich array of meaningful vocal sounds, served to provide hominids with a more accurate *perceptual model* of the environment (Jerison, 1973; Leakey & Lewin, 1977). In their view language evolved at least partly because of the advantages to be gained from increasingly accurate mental representation of the world:

> Our ancestors, ranging as they did over territories far wider than those exploited by their ape cousins, were obliged to construct a mental map of those territories, delineated from many visible reference points, so as to transmit the whereabouts of rich sources of fruit, nuts, and other vegetable foods. This, in turn, would have placed an evolutionary premium on the capacity for detailed perceptual analysis of the environment . . . it makes good biological sense to see language as a rather useful by-product of an ever sharpening pressure to understand and manipulate components of the environment . . . in other words, to think constructively. Naming objects and forming concepts are the key to this ability, thus creating a more sharply delineated world inside one's head and . . . the ability to imagine, to look back into the past, and to project into the future (Leakey & Lewin, 1977, pp. 188, 204).

Any increase in accurate mental representation brought about by language would also have had dividends for a crucial aspect of human biological and cultural evolution—tool making. This is not to say that language preceded the making of tools, or was necessary for this kind of activity. Remains of stone tools date back nearly three million years, and it is possible that our prehuman ancestors were using or even fashioning primitive tools well before the time scientists believe that language could have possibly emerged (Leaky & Lewin, 1977). Also, tool using and making have been observed in living nonhuman primates who have no language. Rather than rendering tool making possible, the emergence of language may have contributed to a higher level of precision and creativity in crafting tools, and in passing on tool-making traditions.

When and How Did Language Emerge?

Sign writing in lumps of clay dating back about five thousand years is the earliest direct evidence for language, but most scientists believe that language emerged much earlier in our history than this. Just how much earlier is a matter of considerable controversy, however. It seems to some authorities that language as we know it is perhaps no older than early *Homo sapiens sapiens*—the Cro-Magnons, who lived around 50,000 to 10,000 years ago. Evidence consistent with this hypothesis comes from comparisons of the skulls of Cro-Magnons with those of Neanderthals, who lived around 110,000 to 30,000 years ago.

Using X-rays of the vocal tracts of animals, speech scientists can determine the potential range of sounds an animal is capable of making. Studies of apes, who unlike humans have a high larynx and small throat cavity, indicate that it would be impossible for them to utter the following vowel sounds: [a] as in *father,* [i] as in *feet,* and [u] as in *boot.* Indeed, apes do not have such sounds in their repertoire of vocal utterances. Interestingly, newborn children have a similar high larynx and small throat configuration, and also do not produce these sounds. Even more interesting is that Neanderthals, unlike Cro-Magnons, also appear to show this configuration. Miller (1981) points out that

> reconstructions of the skull on top of the backbone suggest that Neanderthals, like apes and newborn children, had short necks, high larynxes and relatively small, immobile throats—that, in short, they could not produce the vowels [a], [i], and [u], which are characteristic of modern human languages. According to this reconstruction and simulation, the variety of vowel sounds that Neanderthals could have produced would not have sufficed for vocal communication anything like the speech of modern man (p. 47).

The significance of [a], [i], and [u] vowel sounds lies in the fact that all contemporary languages that have been studied use at least two of these sounds, and most use all three (Miller, 1981).

Of course, such evidence is indirect. In addition, it has been criticized on the grounds that interpretations of incomplete fossil evidence are often a matter of inspired and, perhaps, subjective guesswork. More complete specimens are needed before precise estimations of Neanderthal speech anatomy are possible. And even if Neanderthals were not capable of making the [a], [i], or [u] sounds, there are many other available sounds that could be combined in meaningful ways. In other words, it is still quite possible that Neanderthals, and possibly earlier hominid forms, possessed vocal-auditory communication systems that had most, if not all, of the defining features of language. It is interesting in this regard that hominids of two to three million years ago had already moved significantly toward the human model of a wide throat, with space for a short, thick tongue at the back of the mouth. And there is evidence of an imprint of Broca's area on the inside of the oldest complete skull of a hominid (KNM-ER 1470), which dates back about two million years, probably a form intermediate between the australopithicenes and *Homo erectus.* There is even evidence of a Broca's area in at least one example of *Australopithecus robustus;* although it is much smaller than in KNM-ER 1470, it is impressively larger than the same area in a gorilla's brain (Leakey & Lewin, 1977). Whether any of this means that these forms could talk we will never know. But one thing seems clear: specialization that would allow vocal communication was occurring very early in the history of humans. Most probably the evolution of language was a gradual process spanning millions of years (see Figure 18.2).

What is a likely sequence of evolutionary adaptations that could have cul-

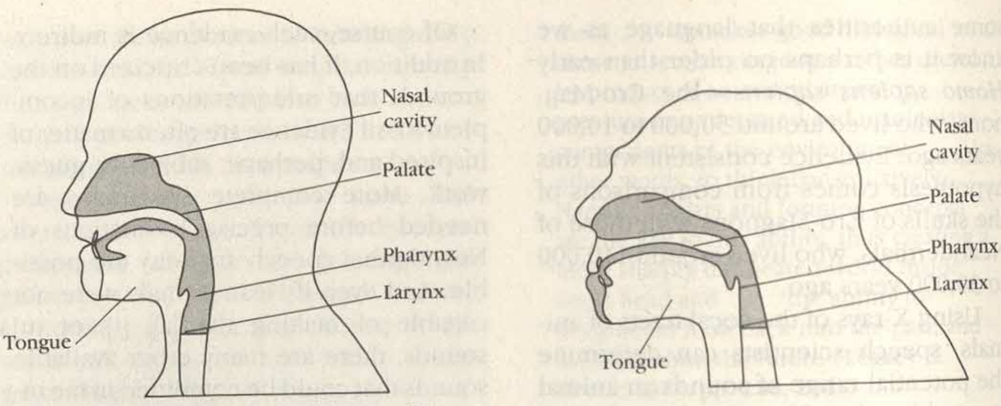


Figure 18.2 Comparison of the vocal tracts of modern humans (*left*) and *Homo erectus* (*right*).

minated in language? Given what we know about brain specialization for speech and the apparent long history of such specialization in hominids, it seems reasonable to speculate that language originated from vocal utterances. There are nonhuman primates (and other vertebrates) living today that are capable of emitting a variety of vocal utterances and reacting appropriately to the vocalizations of members of their own species (Seyfarth, Cheney, & Marler, 1980). Living nonhuman primates are not in the same evolutionary line that produced humans, but it seems likely that *prehuman* primates also had an instinctual repertoire of meaningful vocal signals (Hockett, 1960), perhaps larger than those of apes and monkeys living today. With increases in hominid brain size and organization and changes in vocal anatomy came ever-increasing flexibility. This flexibility would be manifested in at least two ways in later hominids: (1) there would be a significant increase in the *number* of discrete sounds that could be made due to anatomical changes in the vocal tract; and (2) there would be ever-increasing *control* over the production of vocalizations due to increasing neural complexity.

It is conceivable that the *mental capacity* for combining sounds to form primitive sentences preceded the vocal flexibility that is required for such an accomplishment. Certainly chimpanzees and gorillas, with brain sizes and brain-to-body-weight ratios less than one-half those of modern man, have demonstrated the rudimentary ability to *combine* signs after being taught American Sign Language. The vocal anatomy of these animals would not permit them to combine sounds even if they knew how, but when they are allowed to communicate through the use of manual gestures they demonstrate competence in forming primitive sentences, although their sentences may or may not qualify as language.

The cognitive ability to combine words is essential to language. Once hominids began to combine sounds, however early or late in the course of human evolution that may have occurred, it might well have provided impetus for a quantum leap in the evolution of language and brain size. More complex and creative combinations would have been favored because of the tremendous advantages they provide for long-distance hunting, gathering, social cohesion, and mental awareness. Pressure for increases in linguistic complexity would in turn have selected for changes in the brain, most notably the development of a larger semantic memory capacity and the specialization of certain parts of the brain for organizing language.

This scenario is, of course, speculation. Other possibilities are that language evolved directly from manual rather than vocal signals, or that language was "invented" once humans were intelligent enough to conceptualize a language and realize its potential advantages. However, the view that language evolved gradually from the vocal utterances of our prehuman ancestors seems to fit better with the various fragments of evidence we have. The *evolutionary* stages of language may be roughly similar to the early *developmental* stages of language in children (Miller, 1981). We are not suggesting that development repeats evolutionary progressions—that ontogeny recapitulates phylogeny—a notion proposed by the German biologist Haeckel in the nineteenth century and later rejected. But, as Miller states, given that there is so little direct evidence bearing on this issue, the developmental analogy may be no worse than any other as a model for what could have taken place during human evolution:

> Consider it. There is, first of all, the matter of the higher larynx. It serves to prevent babies from choking before they learn to coordinate their alimentary and respiratory tracts. But as the larynx descends into the neck we can observe a progressive enrichment in the child's phonetic repertoire—perhaps there is a clue here to what early speech sounded like. At birth a child utters sounds reflexly to express emotions, much as living primates do. Shortly thereafter we see the appearance of gestural communication, under voluntary control. Then gestures are accompanied by spoken names for objects pointed to or reached for; the names become progressively differentiated and become independent of the gestural system. These words are soon combined, though with little respect for word order. As utterances grow longer, recognizable syntactic patterns are adopted to organize them. Learning the inflated vocabulary of modern industrial society continues into adulthood—if, indeed, it ever stops.
>
> Once we get over a distaste for looking at children as living fossils at different stages of evolution, the above description of their language development does not seem an unreasonable scenario for the evolution of human language (p. 120).

The Development of Language

As we saw in Chapter 6, very young infants seem already perceptually attuned to speech sounds. They are not blank slates with respect to language acquisition; they appear to be biased biologically in the direction of processing linguistic information in their environment.

Prelinguistic Vocalizations

Infants begin to produce recognizable vowel and consonant sounds as early as the first ten days of life. The vowel sounds include those associated with the letter ***a*** in *fat,* ***e*** in *pet,* ***u*** in *mutt,* and ***i*** in *bit.* The most frequently heard consonant sounds at this time are those associated with the letter ***h*** in *horse,* ***k*** in *king,* and ***w*** in *walk.* These first sounds appear to bear little relation to the

A ten-month-old is "conversing" with great-grandmother.

sounds the child hears, since babies throughout the world produce the same initial set of vocal sounds, regardless of the language spoken by their parents. Some of these elementary sounds will not be produced later in the child's life, however, and those that are retained occur in the child's native language.

During the first four weeks of life vowel sounds outnumber consonant sounds by about 5 : 1. After this time consonant sounds increase at a rapid rate, so that by twelve months of age the child emits slightly more consonant sounds than vowel sounds. The adult ratio is about one and a half consonants for each vowel.

Over the years there has been some controversy among psychologists and linguists over the significance of the sounds made in early infancy. Are the infant's early vocalization and babbling *continuous* with later language accomplishments? Or is the development of intelligible speech relatively *independent* of these early sound productions? There is evidence consistent with both views, but a systematic longitudinal analysis of five infants has revealed striking similarities between the phonetic content of babbled utterances and later speech (Oller, Wieman, Doyle, & Ross, 1976).

One-Word Utterances

By the end of the first year of life many children begin to utter sounds that are meaningful to others. Initially these may take the form of single words such as *ma, mama, pa, papa, da, dada,* and other consonant-vowel combinations that appear to refer to the child's caregivers or to others in the home environment, including pets. Single-word utterances increase in number rapidly, and they come to sound more and more like adult utterances. They also increasingly take on greater varieties of meaning.

Although infants one to two years of age spend a good deal of time naming things with their one-word utterances, their single words appear to carry additional functions. In other words, the child may use the *same* word to mean a *variety* of things. Researchers studying child language have noted that the utterance *mama* seems to be simple naming on some occasions, naming of the instigator of an action on other occasions (for example, when "mama" dresses the child), and on still other occasions a request, as when the child wants "mama."

During their second year of life children apparently know a lot more than they can tell us about. Their speech productions are more limited by physiological immaturity than their cognitions are. Supporting evidence for this hypothesis is the observation that children at this age can respond appropriately to linguistic expressions they could not possibly produce. For example, many eighteen-month-olds have little difficulty complying with the request "Bring Daddy his shoes." They would be unable to reproduce this utterance, however.

First Sentences

At about eighteen months of age some children begin to form their first sentences. Initially these consist of two-word combinations, such as "Where mama?" "Throw ball," "Daddy go," and "More milk." The remarkable thing about these early sentences is that they convey meaning using only two words. In order to do this, the words chosen must be the most important content words available for expressing a thought. Because of the economical nature of children's earliest sentences, they are referred to as **telegraphic** speech. Words that embellish a sentence but are not essential to its basic meaning are not included in the typical two-year-old's productions. Such "frilly" words are called **functors;** they include prepositions, conjunctions, articles, auxiliary verbs, copular verbs, and inflections.

Thus a child's first two-word combinations usually are not random; they are precisely the words needed to convey a thought, such as describing an action or indicating possession or location. And typically there is a consistency of order with respect to the two words—the agent (subject) precedes the action (verb), and the thing acted upon (object) follows the action, at least in English and certain other languages. The early appearance of appropriate word order, and the fact that there is a great deal of uniformity in the kinds of meanings expressed in two-word utterances in various languages, suggest that the linguistic productions of the two-year-old are closely tied to the child's cognitions. In other words, it is as if the child knows that causal sequences characterize the environment—there are agents, actions, and things acted upon. This knowledge attunes the child to the precise words, word combinations, and word orders needed to convey various thoughts to others.

Further Accomplishments

During the brief period between eighteen and twenty-four months the number of two-word combinations children can utter can go from near zero to two or three hundred. From approximately two to four years of age children's sentences become longer and more capable of conveying precise meaning. This comes about through the acquisition of the functors that are so notably absent in the speech of a two-year-old. The order of acquisition of functors is remarkably consistent, as is indicated by the results of Roger Brown's (1973) longitudinal study of language in three children—Adam, Eve, and Sarah (Table 18.1). All three children showed the order of acquisition listed in the left-hand column of the table, with only a few variations. Other studies using larger numbers of children have confirmed Brown's findings.

Why the consistent order? Word endings such as *-ing* and *-on* precede the use of past tense and plural forms, and auxiliary verbs such as *is, was,* and *were* follow. Brown concluded that the forms that are the least complex in terms of the number of meanings they can convey are acquired first. For example, *were* as an auxiliary can convey number (plural) or something happening earlier in time (past tense), and also can refer to an ongoing process (for example, "They *were* on their way home"). The use of *-s* or *-es,* on the other hand, means only one thing—plural. Thus the earliest functors acquired carry the fewest meanings.

An alternative explanation of this pattern of acquisition is that the earliest

TABLE 18.1 Order of Acquisition of Functors

Form	Meaning	Example
1. Present progressive: **-ing**	Ongoing process	He is sitt*ing* down.
2. Preposition: **in**	Containment	The mouse is *in* the box.
3. Preposition: **on**	Support	The book is *on* the table.
4. Plural: **-s**	Number	The dog*s* ran away.
5. Past irregular: e.g., **went**	Earlier in time relative to time of speaking	The boy *went* home.
6. Possessive: **-'s**	Possession	The girl'*s* dog is big.
7. Uncontractible copula **be**: e.g., **are, was**	Number; earlier in time	*Are* they boys or girls? *Was* that a dog?
8. Articles: **the, a**	Definite/indefinite	He has *a* book.
9. Past regular: **-ed**	Earlier in time	He jump*ed* the stream.
10. Third person regular: **-s**	Number; earlier in time	She run*s* fast.
11. Third person irregular: e.g., **has, does**	Number; earlier in time	*Does* the dog bark?
12. Uncontractible auxiliary **be**: e.g., **is, were**	Number; earlier in time; ongoing process	*Is* he running? *Were* they at home?
13. Contractible copula **be**: e.g., **-'s, -'re**	Number; earlier in time	That'*s* a spaniel.
14. Contractible auxiliary **be**: e.g., **-'s, -'re**	Number; earlier in time; ongoing process	They'*re* running very slowly.

Source: R. Brown (1973) cited in Clark & Clark (1977).

Acquisition of fourteen functors in the speech of three children. Functors are listed from top to bottom (left-hand column) according to when they appeared in the children's speech.

forms used are also the ones heard most frequently in parental conversation. So the child may simply first imitate the forms that occur most often in adult speech. Brown investigated this possibility by analyzing the frequency of different functors in the speech of the children's parents and found no support for the hypothesis. Parental usage did not predict the order of acquisition in the children's speech.

> This is an important conclusion because most imitation and reinforcement theories of learning have assumed that frequency of exposure to any behavior is a critical factor in learning: The more frequently children hear a word, the sooner they should learn it. Yet here is a case where children's order of acquisition appears to bear no relation to the frequency of usage by parents. . . . Children have to hear a morpheme [functor or other meaningful sound] before they can acquire it, but those morphemes they hear most frequently are not necessarily the ones they acquire first. All this evidence suggests that children add function words and suffixes to their utterances with great consistency: different children acquire grammatical morphemes in virtually the same order. Moreover, during acquisition, they consistently go through several stages in constructing rules for the use of each morpheme. Their reliance on rules shows up in their overregularization of word endings like the past tense *-ed* (added to regular and irregular verbs alike) or the plural *-s* on nouns (added to all nouns). Eventually they refine these overgeneral rules till they match those used by adults, but may take several years to complete the details (Clark & Clark, 1977, p. 346).

The phenomenon of overregularization deserves some elaboration. Overregularization occurs as soon as infants learn their first words. Many parents have heard their toddler use the word *doggie* to refer to any four-legged creature—dogs, cats, cows, or even elephants at the zoo. And later, as the Clarks indicate, children will learn a rule, such as that governing the formation of past tense, and apply it without regard for the exceptions. This is most apparent when children add *-ed* to irregular verbs such as go *(goed)* and come *(comed)* in order to convey past tense. Some children, including those of one of your authors, add two *-ed* sounds *(goeded),* almost as though they are trying to make doubly sure the intended meaning is conveyed. The significance of overregularization is not that children make silly mistakes during language acquisition, but rather that these errors arise because children are continually learning the rules of their native language. It is as if children are constantly developing and modifying theories about how language works, from infancy on. They test their theories by applying the rules they think will work to get others to understand what they mean. Then the rules are modified and refined in accordance with the data provided by the feedback they receive from listeners and speakers in their environment.

By the time children are about three years old they use negatives and interrogatives in a fashion that approximates adult usage. For example, a three-year-old is apt to say things like "No, I don't have a book" (negative) or "Can I have another piece of paper?" (interrogative). Contrast these sentences with the typical negatives and interrogatives of children at the two-word stage: "No book!" (negative) and "More paper?" (interrogative). Also, by three years of age children are beginning to form complex sentences that combine several propositions using clauses. For example:

"The window *the boy hit* was big."

"I was crying *when* my mummy goed away."

"We'd better get down *before* she comes."

By the time children are four to five years of age they have acquired and know how to use most, if not all, of the basic rules of their native language. Of course their speech is not as grammatical as it will be later in life, nor is their vocabulary as extensive, and they are not sophisticated in terms of distinguishing fine shades of meaning from spoken sentences. Nevertheless, children of this age have all the linguistic equipment they will need to extract basic meanings from the speech of others, and to use speech in a manner that is intelligible to others.

How Is Language Acquired?

Considering the complexity of language, the ease and rapidity of its acquisition are impressive. Some language theorists are so impressed by these features that they believe humans are genetically programmed for language processing and learning. Other theorists see no need for inferring an innate language processing structure; they argue that language is acquired by relatively simple learning mechanisms (Whitehurst, 1982).

Probably classical conditioning, instrumental learning, and observational learning all play important roles in the child's acquisition of words and word meanings. Classical conditioning, especially higher-order conditioning and stimulus generalization, may explain why certain words or phrases come to elicit particular feelings or mood states when we hear them. The idea is that these words, at one time neutral in character, became associated with stimuli capable of eliciting strong feelings. The phrase "You go to hell!" is bound to stir feelings of hostility, anger, or fear in most of us. Perhaps this is because we were once on the receiving end of this expression and it was accompanied by a loud voice, angry facial gestures, and perhaps even physical violence. Or we may have been made anxious by seeing or reading about others who reacted adversely to an aggressor who used this particular phrase.

It is also easy to imagine that instrumental learning shapes speech. When the speech of young children closely resembles the speech of their parents, they may be more likely to receive reinforcement in the form of praise, smiles, and hugs. There is in fact a good deal of evidence to suggest that these kinds of reinforcers are quite effective in increasing babbling sounds in infants (Rheingold, Gewirtz, & Ross, 1959). Babies will even increase vocalizations of one type over those of another depending upon which kind of sound is reinforced and which is not (Routh, 1969). This suggests, at the very least, that infant vocal behavior is responsive to environmental reinforcers (see Figure 18.3).

Finally, it is clear that observational learning plays an important role in language acquisition. Children do imitate what they hear, and as a result acquire a sizable vocabulary and perhaps other linguistic information as well. In fact, mothers spontaneously model *simplified* sentences with accentuated stress when speaking to their infants, perhaps unconsciously making the task of language learning easier for the child (Snow & Ferguson, 1977).

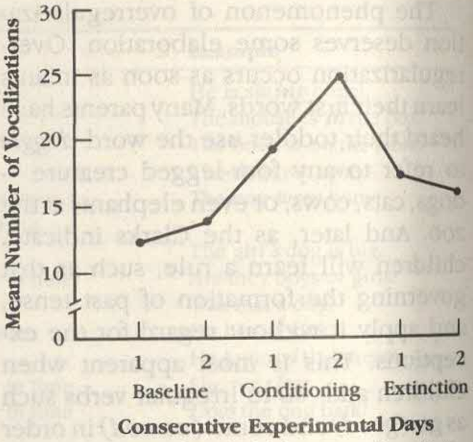


Figure 18.3 Infant babbling as a function of the presence of social reinforcers—talking to, smiling at, and touching the baby. Reinforcement is given contingent upon the infant's vocalizing, but only during the conditioning phase of the study.

But some experts on language argue that these established principles of learning do not tell us much about how children acquire the *rules* of language so rapidly. The rules are never modeled directly; children must extract them or infer them from the tremendous variety of sounds they hear. How is this accomplished so rapidly?

Some language theorists (for example, Chomsky, 1975) have argued that some of the rules may have an innate basis, such as the child's concept of the underlying structural properties of a sentence. In other words, children may have some innate knowledge which directs them in understanding how language is organized and how it works. Other theorists argue for the existence of an innate tendency to pay special attention to those aspects of speech, such as word order in sentences, that are critical for revealing the rules of language (Slobin, 1973). Still other theorists contend that children make sense out of language rapidly because of their rapidly developing symbolic abilities and active cognitive processing of the environment. This cognitive view stresses that language learning requires no *special* innate rules or predispositions; language is essentially no different from other cognitive activities (Reynolds & Flagg, 1983).

Language and Thought

Does language *determine* the way we think, or is it a *reflection* of the way we think? This question has been debated for many years and has stimulated a good deal of research. An influential view was put forth by the American linguist Edward Sapir, and later modified and elaborated by his student Benjamin Whorf (1956). This position, referred to as **linguistic determinism,** holds that language precedes and determines thought; it has come to be called the "Whorf hypothesis." Whereas Sapir had taken a moderate position, theorizing that thinking is *influenced* by language, Whorf argued that all higher levels of thinking *depend* upon language. A corollary of this extreme hypothesis states that different languages produce different perceptual and cognitive pictures of the world. This corollary is often referred to as the hypothesis of **linguistic relativism.**

It is not clear that Whorf actually distinguished between linguistic determinism and linguistic relativism. In any case, they should be distinguished, because it is logically possible for one of them to be correct but not the other. For example, language may determine thought for all people, but the speakers of different languages may have similar language constructions that affect thinking in similar ways. In this case linguistic determinism would be true but linguistic relativism would be false. In contrast, language may not determine thought, but speakers of different languages may perceive things differently anyway, owing to differences in their environments or genetic constitutions. In this case linguistic determinism would be false but linguistic relativism would be correct (Dale, 1976).

Here is how Whorf elaborates the notion of linguistic determinism:

> We dissect nature along lines laid down by our native languages. The categories and types that we isolate from the world of phenomena we do not find there because they stare every observer in the face; on the contrary, the world is presented in a kaleidoscopic flux of impressions which has to be organized by our minds—and this means largely by the linguistic systems in our minds. We cut nature up, organize it into concepts, and ascribe significances as we do, largely because we are parties to an agreement to organize it in this way—an agreement that holds through our speech community and is codified in the patterns of our language (p. 213).

The evidence in support of linguistic determinism and relativism comes mainly from cross-cultural analyses of different linguistic terminologies and structures. In his travels across the United States as an insurance salesman, Whorf was impressed by the striking difference he observed between Native American languages and those of Western Europe. Whorf and others have observed that, in many instances, direct word-for-word translation from English to one of the Native American languages is impossible. A meaningful sequence of English words translated directly into Navaho may be nonsensical to a Navaho. For example, the sentence "I drop it" is generally meaningful to us, although the precise meaning—what "it" refers to—

The Eskimos' language contains many more names for certain features of the environment than does English. Does this mean that Eskimos perceive more of these features than native speakers of English?

can only be determined by context. But this same sentence does not express an intelligent thought in Navaho. Navaho must specify more particulars—such as whether "it" is definite or indefinite; whether the object is round, long, animate, or fluid; whether the act is in progress, about to begin or end, or carried on repeatedly or habitually; and the extent to which the agent ("I") has control over the dropping (Spencer & Jennings, 1965).

Differences in terms used to name things also suggested to Whorf and other linguistic determinists the possibility of differences in the perceptions of those things. For example, the Eskimo have many more terms than English speakers do for different kinds of snow and different species and characteristics of seals, two environmental stimuli of crucial significance for Eskimo survival and culture. The linguistic determinist would argue that these differences in Eskimo and English are responsible for different perceptions in the speakers of these two languages. English speakers may not *perceive* many of the variations in snow or seal attributes that Eskimo speakers do because they have no terms denoting such variations.

One major weakness of Whorf's hypothesis is that it is based upon circular reasoning. Whorf observes that there are differences among various languages such as those we have described; because of these differences he argues that speakers of different languages think differently, a rather long conceptual leap. Then Whorf concludes that the cognitive differences he has *assumed* have arisen from the differences in language. As Dale (1976) notes, ". . . differences in language prove only that languages differ. Without an independent measure of the thought patterns themselves, no conclusions can be drawn" (p. 241).

Another difficulty for the Whorf hypothesis is posed by research that highlights the basic *similarities* among languages—language universals. We have already mentioned that the timing of emergence and the order of acquisition of linguistic structures in children is remarkably similar from one language to another. The basic structures and rules themselves also are highly uniform across languages. For example, nouns and verbs occur in all languages, and all languages have rules that use word order or inflections to convey meaning. There are many differences among languages, to be sure, as anyone knows who has tried to master a foreign language. But the basic principles of language show far more similarities than differences.

A final piece of evidence dealing with color terms seems quite damaging to the Whorf hypothesis. Different languages often use terms that divide the color spectrum in different ways. Some languages, including English, have terms for eleven distinct basic colors: in English these are *black, white, red, yellow, green, blue, brown, purple, pink, orange,* and *gray.* At the other extreme is the language spoken by the Dani, a New Guinea tribe. The Dani have only two color terms — *mili* (black) and *mola* (white) — to cover the entire color spectrum. In spite of the variations in color terms among languages, one generalization emerges from the research: colors that are most easily named, regardless of language, generally are those that are remembered most accurately in recognition memory tests.

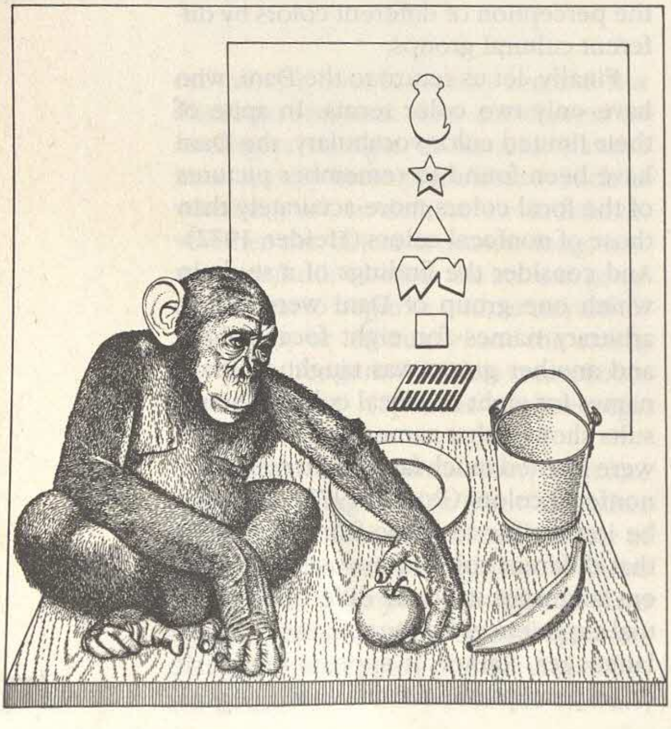
But how is this observation damaging to the Whorf hypothesis? The fact that it is the *verbal* codability of colors that determines how well they can be remembered actually seems quite consistent with the position of linguistic determinism. However, our account of color naming has a rather surprising conclusion. It turns out that for any language, colors that are easiest to name are also those that are perceived as the best examples of these color terms (Berlin & Kay, 1969; Kay, 1975). These "best instances" of colors are referred to as *focal* colors. For example, in English the particular shade of red that can be identified as *red* most quickly and remembered best is the *same* for all English speakers, and is agreed upon as the best example of the color red. Moreover, if a language other than English includes a word for *red* as a basic color term, the same phenomenon holds for speakers of this language — they can identify faster and remember most accurately the focal color, the shade of red that they agree is the best representative of the color red. Even more surprising is the fact that this shade of red will be the identical shade that was picked by English speakers, or by speakers of other languages whose color lexicon includes a term for red. In other words, any given color term appears to refer to the same perceptual experience — the focal color — among speakers of any language that uses a basic term for that color.

Furthermore, if a language has only two color terms, we can reliably predict which colors they will be — black and white. A language with four color terms will have words for black, white, red, and yellow. In general, if the number of color terms for a language is known, we can predict which terms they will be by proceeding from left to right (*black* to *gray*) through the eleven color terms listed earlier. This hierarchy of color terms certainly suggests a uniformity in the perception of different colors by different cultural groups.

Finally, let us return to the Dani, who have only two color terms. In spite of their limited color vocabulary, the Dani have been found to remember pictures of the focal colors more accurately than those of nonfocal colors (Heider, 1972) And consider the findings of a study in which one group of Dani were taught arbitrary names for eight focal colors, and another group was taught arbitrary names for eight nonfocal colors. The results showed that names for focal colors were learned much faster than names for nonfocal colors (Rosch, 1973). It would be impossible to argue from these data that different color terms used in different languages structure different perceptual experiences for the speakers of these languages. Rather, it appears that basic color perceptions are the same, regardless of the different ways the color spectrum is divided from one language to another. This evidence is clearly inconsistent with the Whorf hypothesis.

Sapir's hypothesis holds that language *influences,* rather than determines, thought. This seems intuitively appealing, and more reasonable than Whorf's notions. It is also supported by a good deal of empirical evidence. A prominent psychologist who has argued in favor of this more moderate hypothesis, Jerome Bruner, has theorized that the perceptual and cognitive world of infants and preschool children is restricted to the "here and now" because they have not yet internalized language as a tool for thought. Between the ages of about five and seven years, according to Bruner, children begin to use language to help them think. They internalize verbal rules to help them solve problems, to remember things, to reason about things abstractly, and to otherwise represent and transform information. The transition to a "symbolic" (verbal) mode of cognitive representation is a gigantic step forward, allowing the child enormous cognitive flexibility and power (Bruner, 1964). Other researchers, most notably the Russian psychologists L. S. Vygotsky and A. R. Luria, have made arguments similar to those of Bruner, although according to them the age at which language begins to be internalized is somewhat earlier.

Sarah learned to communicate with plastic symbols.



That language can influence thought is seen clearly in research on one aspect of thought—memory. It is apparent, for example, that the use of verbal strategies such as categorization and rehearsal facilitate the transfer of information from short-term to long-term memory in deliberate memory tasks (see Chapter 13). Preschool children tend to rely less on verbal rehearsal than older children, and categorization ability tends to improve throughout childhood. Correspondingly, older children and adults are generally more effective memorizers than are younger children.

We cannot resist including a final tantalizing bit of evidence for the influence of language on thought. You may recall the discussion in Chapter 4 of how David Premack trained Sarah and other chimps to communicate with plastic symbols representing words and concepts. Sarah acquired a vocabulary of about a hundred "words," as well as the ability to understand and communicate concepts such as negatives, same-different, names for things, and attributes of those things. Moreover, she was able to combine and arrange her plastic chips to form primitive sentences.

Premack (1983) reports that chimps such as Sarah who have received this kind of language training in his laboratory stand out *conceptually* from other chimps that had not been trained. Language-trained chimps were able to solve novel problems requiring more complex, abstract solutions compared to chimps who had received comparable amounts of attention but no language training. It is possible that this finding may simply reflect a sampling bias — the chimps used in the language training studies may have been inherently smarter than those who were not included. However, Premack has some anecdotal evidence that argues against sample bias as an explanation.

We will need better controlled comparisons than these before drawing any firm conclusions, but there is at least the suggestion here that language aids thought. The possibility that this phenomenon might also apply to nonhumans is fascinating.

There are a few scholars who take an extreme position opposite that of linguistic determinism. Most notable among them is Piaget, who argued that thought *precedes* language and is reflected in language. Piaget did not deny that language could influence some aspects of thought, but he believed it did not make a substantial difference in the emerging structures of cognition. The views of most students of language and cognition lie somewhere between those of Whorf and Piaget. There is no question that language shapes thought, but it seems highly unlikely that all forms of higher thinking depend on language.

Individual Differences in Behavior

Chapter 19 Personality: Theories and Assessment

Chapter 20 Intelligence and Intelligence Testing

Chapter 21 Abnormal Behavior

Chapter 22 Modifying Abnormal Behavior

UNIT VII

For the most part our emphasis thus far has been on understanding general principles of behavior, rather than individual differences. Although we will continue to be concerned with general principles of behavior, the last four chapters in the text emphasize the ways people differ from one another, and some of the major reasons for such differences.

One of the ways people differ is in their personalities. In fact, the concept of *personality* refers to all of the traits that make each individual unique. We share many basic features of personality with others, but each person has a distinct combination of these features. Several psychological and biological theories have been devised to explain the structure, function, and development of personality in general, as well as individual differences in personality.

Intelligence is one of the most obvious features of personality, a feature that shows considerable variation among individuals. Although we often think of intelligence as a general cognitive ability that allows us to adapt to the environment, tested intelligence — the IQ — represents only a narrow sample of this ability. Interpretations of IQ that have compared the relative contributions of heredity and environment have stirred considerable controversy within psychology as well as among the general public.

Perhaps the most dramatic individual differences in behavior are those classified as abnormal behavior. By definition, abnormal behavior is unusual behavior, but being unusual is not enough to classify behavior as abnormal. Abnormal behavior is usually culturally inappropriate, may involve significant personal distress, and may interfere with a person's ability to cope with family, friends, and occupation. Major theories of personality offer contrasting procedures for treating various kinds of abnormal behavior.

19

Personality: Theories and Assessment

What Is Personality?

Biological Theories

Psychoanalytic Theories

Learning Theories

Humanistic and Existential Theories

Assessment of Personality

Stability of Personality

Supplement 1 Cognitive Dissonance: A Theory of Rationalization

Supplement 2 Ethnic Differences in Infant Temperament

Chapter Preview

Personality refers to the distinctive patterns of behavior that characterize an individual's adaptation to the environment. Personality theory and research have attempted to describe and explain the *common elements* as well as the *individual differences* in personality.

Four major kinds of personality theories are discussed: biological, psychoanalytic, learning, and humanistic and existential. *Biological theories* include those that relate differences in personality to *body types*. There are also theories, such as Eysenck's, that relate differences in personality to *genetic factors*.

The major *psychoanalytic theory* of personality is that of Freud. Freud believed that *unconscious* conflicts and motivations play a large role in structuring personality, which he divided into *id* (the pleasure principle), *ego* (the reality principle), and *superego* (the conscience). He also hypothesized several stages of personality development: oral, anal, phallic, latency, and genital. Although Freud's theory is difficult to test empirically, and few psychologists accept it in its entirety, Freud gave us the important concept of unconscious motivation and emphasized the importance of early experience in shaping personality.

Other psychoanalysts developed their own versions of Freudian theory, most notably Freud's early followers Alfred Adler and Carl Jung. Other prominent neo-Freudians are Anna Freud, Karen Horney, Harry Stack Sullivan, and Erik Erikson.

Learning theories of personality are based upon principles of classical conditioning, instrumental learning, and observational learning. These theories characterize personality in terms of *overt behavior* and emphasize *external environmental factors* that influence personality. Contemporary applications of learning theory to personality center around the ideas of Skinner and Bandura.

Humanistic and existential theories of personality focus upon the *conscious* elements of personality, unlike Freudian theory. They emphasize individual uniqueness and freedom of choice more than do other personality theories. Humanistic theorists such as Carl Rogers and Abraham Maslow emphasize that we are innately motivated to *self-actualize,* to develop our potentials to the fullest. Many existential theorists place a greater emphasis on individual freedom and responsibility, and some do not take the positive view of human nature espoused by the humanists.

As the variations in personality theory suggest, personality has many facets, and this makes objective assessment difficult. Nevertheless, psychologists have devised a number of procedures and tests for classifying various aspects of personality. These include interviews, case histories, personality inventories, projective techniques, and direct observations of behavior.

A major controversy in the area of personality concerns the stability of traits and overt behavior in different situations. Even though there is much variation in a person's behavior, it would be unwise to conclude that there is nothing stable about personality.

The first supplement to this chapter describes cognitive dissonance theory, one explanation of the defense mechanism known as rationalization. Cognitive dissonance theory is a general theory of behavior proposed by social psychologists. In the second supplement we describe arguments and data suggesting that differences in infant temperament may be related to race.

What Is Personality?

You are well aware from reading other sections of this text that defining or characterizing psychological concepts is not always easy. Actually, the most difficult part is arriving at definitions or characterizations that other psychologists will find-acceptable. No psychological concept is exempt from this difficulty, but the concept of personality is especially vulnerable.

The term **personality** derives from the Latin root *persona,* meaning the mask worn by an actor. Later *persona* came to mean a person's facade, or the social role a person plays. Certainly this connotation of a "front" that hides other personal traits and qualities is *one* aspect of personality. But the concept of personality has many more facets. Our everyday use of the term *personality* is evidence of the varied meanings associated with the concept: "She really has a lot of personality" . . . "He's good-looking, but he has a terrible personality" . . . "Albert Einstein was a noted scientific personality" . . . "Must the two presidential candidates stoop so low as to indulge in personalities?" In addition, the fact that there are so many personality *theories* in psychology attests to the fact that the concept of personality involves many different properties.

Although there are many possible definitions of personality, psychologist Walter Mişchel's is probably as useful as any for beginning our consideration of this topic: "Personality usually refers to the distinctive patterns of behavior (including thoughts and emotions) that characterize each individual's adaptation to the situations of his or her life" (1976, p. 2). What Mischel's definition says is that personality refers to *all* of the things that make you *you* and me *me*. Although all of us share many of the same patterns of thought and emotion, motivations, and other elements of personality, each of us possesses a *distinct* combination of these things. Personality theory and research have attempted to describe and explain the *common elements* as well as the *individual differences* in personality.

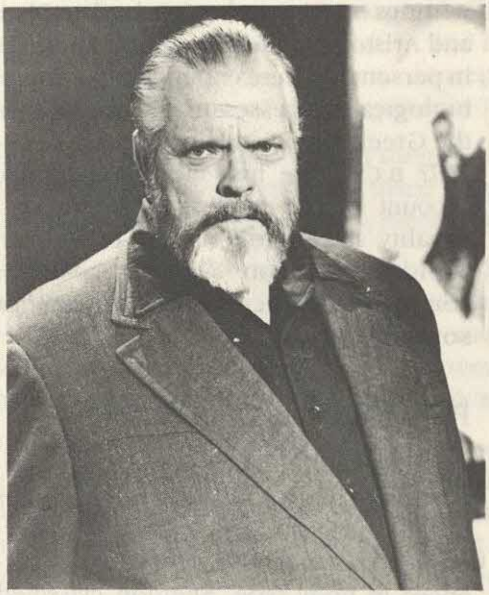
Biological Theories

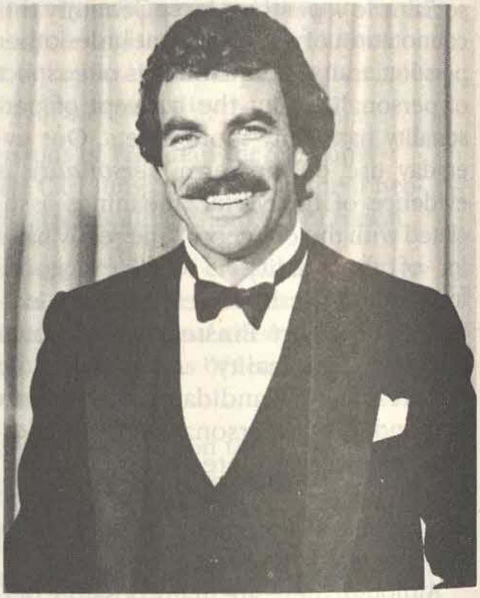
The earliest conceptions of human personality were rooted in biological structures and functions. Prescientific writings on the psyche date back to Plato and Aristotle, and individual differences in personality were explained in terms of biological processes in the writings of the Greek physician Hippocrates (460?–377? B.C.). The first modern scientific account of the relation between personality and biology is that of William Sheldon (Sheldon & Stevens, 1942), commonly referred to as *body type* or **somatotype theory.**

Personality and Body Types

Sheldon, building on the ideas of a German psychiatrist named Kretschmer (1925), proposed that individual differences in personality are related to differences in body type. Sheldon classified three major body types—**endomorphy** (fat), **mesomorphy** (muscular), and **ectomorphy** (lean). Using photographs and physical measurements, Sheldon found evidence for seventy-six different types of body build, variations of the three major classifications. More important, Sheldon claimed to have found evidence for three different kinds of temperament that were correlated with the three different body types. Sheldon reported that endomorphs were generally extroverted and sociable, mesomorphs were often aggressive, adventurous, and assertive, and ectomorphs were typically introverted and inhibited. He also claimed to find a relation between body types and different kinds of abnormal behavior.

Unfortunately, Sheldon's methods of rating temperament were not as objective as they might have been. For example, it was Sheldon and his associates who did the personality ratings, which raises the possibility that theoretical expectations may have biased the results. In fact, more carefully controlled studies





Which body-personality type (mesomorph, endomorph, ectomorph) would you assign to each of the celebrities in the photos, and why? Orson Welles *(above left)*, Woody Allen and Mia Farrow *(left)*, Tom Selleck *(above right)*.

generally have not reported correlations between body type and temperament as high as those claimed by Sheldon and his colleagues. Nevertheless, some studies show a modest but consistent correlation in the direction that Sheldon hypothesized (Janis, Mahl, Kagan, & Holt, 1969).

The fact that there may be a relationship between body type and personality tells us nothing about the *nature* of such a relationship. Is it the differential reactions of others, such as family and peers, toward people with different body types that account for the relationship? Or might there be some constitutional factor, such as different rates of metabolic activity or different concentrations of hormones, that produces various body-types as well as temperaments? Are changes in body type during one's life followed by changes in personality, or vice versa? Answers to such questions must await further research.

Genetic Theories

It is possible that variations in certain aspects of personality can be accounted for, in part, by different genotypes. This is not to say that instructions for making personalities are contained in the DNA; genetic influence could be quite indirect. For example, different gene combinations can cause variations in height. People who are significantly shorter or taller than average undoubtedly encounter distinct perceptions, expectations, and reactions from others, which may influence their personalities in different ways. In this example, genotype would be related to individual differences in personality, but only indirectly.

Genetic influence on personality need not be as indirect as suggested by the example of body height, however. Psychologist Hans Eysenck hypothesized that a very important dimension of personality is *introversion-extroversion,* also called **sociability.** He argued further that individual differences in sociability are influenced by genetic factors. But how would genes contribute to whether a person is introverted or extroverted? Eysenck proposed that different genotypes can produce various levels of cortical arousal in the brain. Persons with extremely high levels of central nervous system arousal, for example, would be overly sensitive to the environment. They would find it difficult to habituate to stressful stimuli, and would develop conditioned fear responses and avoidance responses rather easily. They would tend to shy away from external stimulation, including social stimulation, and thus be characterized as introverts. But individuals with very low levels of CNS arousal would be "hungry" for stimulation. They would try to raise existing cortical arousal by seeking external stimulation, including social stimulation, and thus be characterized as extroverts. Of course, most people would fall somewhere between these extremes.

Scales for rating introversion-extroversion were developed by Eysenck and others, allowing for quantification of this dimension of personality. Research using such scales has produced evidence to support Eysenck's contention that introversion-extroversion is influenced genetically. Twin studies show that identical twins raised together or apart are more alike in sociability than are fraternal twins (Buss, Plomin, & Willerman, 1973; Scarr, 1969), and this difference can be detected as young as the first year of life (Freedman & Keller, 1963). Researchers have also observed that there are individual differences in preferences for external stimulation during infancy; some infants seem to be attracted to extremely novel visual and auditory environments, while others prefer less change and stimulation. Identical twins show more similarity than fraternal twins in preference for stimulation, a trait closely related to introversion-extroversion (Hetherington & Parke, 1979).

There is increasing evidence to support genetic theories of personality such as Eysenck's. We have mentioned elsewhere in the text that certain temperamental characteristics show striking stability from infancy on (Thomas, Chess, & Birch, 1970), and that identical twins raised in separate environments show surprisingly strong similarity in a variety of personality characteristics (Farber, 1981). And genetic influence on temperament in nonhumans, including sociability, has been well documented for some time (Fuller & Thompson, 1960; Scott & Fuller, 1965). This does not mean that variation in all or most aspects of personality is due to genotype. So far, most of the evidence for genetic influence concerns the sociability dimension of personality. And, to say that there is genetic influence on sociability implies an interaction of genotype with the environment. Table 19.1 indicates how complex such an interaction might be.

Evaluation of Biological Theories

Few if any psychologists would deny that biological factors influence personality to some extent. Nevertheless, biological theories of personality to date have been somewhat disappointing because they are rather vaguely formulated. Biological theories need to address several questions: How might the physical constitution of an individual influence personality directly or indirectly? Precisely which constitutional factors—body type, metabolic rate, hormones, neurotransmitters—would be expected to play roles in structuring personality, and what roles would they play? To what extent are constitutional influences on personality tied to genetic factors? How would different environments be expected to modify constitutional influences on personality? There are now sufficient data to justify more systematic and well-specified biological formulations that make precise statements about expected genotype-constitutional-environmental interactions and their influence on personality.

TABLE 19.1 One Possible Interaction of Genotype and Environment

Genotype	Environment		
	Unsociable	*Sociable*	*Highly Sociable*
Low CNS arousal	Moderately sociable	Highly sociable	Highly sociable
High CNS arousal	Sociable	Unsociable	Unsociable

A *possible* interaction of genotype and environment in determining level of sociability. Such an interaction indicates that the same genotype may be expressed differently in different environments. Note that this interaction is not based on actual data; it is only one among many possible interactions.

Psychoanalytic Theories

We introduced Sigmund Freud as the founder of the psychoanalytic movement in Chapter 2. Freud's theorizing about personality was extremely influential, and many of his notions about the structure and development of personality continue to influence students of personality and practitioners in mental health professions.

The Structure of Personality

Freud's theory is grounded in biological motivating forces, and thus could qualify as a biological theory of personality. Freud believed that we are all born with life-preserving instincts, which he called *Eros.* These survival and reproductive instincts (needs, motives) give rise to psychic energy—**libido**—that impels the organism to act in ways that will promote self-preservation and propagation. Impulses associated with libido are primarily *sexual* in nature, according to Freud, although the term *sexual* in this context refers to a broad class of biological motives and pleasure-seeking phenomena, not just to sexual desire and physical arousal involving the reproductive organs. Libidinous impulses can also be *aggressive* in nature, functioning to satisfy underlying sexual motives. Later in his career, Freud believed that aggressive impulses could be motivated independently of sexual needs. In fact, he created the concept of a "death instinct," called *Thanatos,* to go along with Eros. Apparently this modification in Freud's theory was inspired in part by his observations of hostility and destruction of life during World War I.

According to Freud, the libido is "contained" in the **id**, one of three major components of personality. Basic needs produce an increase in libido, which is experienced as physiological tension. The id converts this tension into an impulse or desire, which, if gratified, will reduce the tension. The id is *hedonistic* in nature; that is, it is geared to producing *pleasure* in the individual. It is also *irrational;* pleasure-seeking is the primary aim of the id, regardless of constraints imposed by the environment. It is not surprising that the id is often called the "pleasure principle" of personality.

The second major personality component is the **ego.** The ego represents the *rational* part of personality, and is often referred to as the "reality principle." In effect, the ego works in service of the id, trying to satisfy the individual's needs, but it does so in a realistic fashion. For example, a seven-month-old infant sees her favorite rattle situated on the other side of a closed, sliding glass door, and attempts to crawl through the glass door to get it. This attempt at *immediate gratification* is directed by the id. The ego, which develops because of frustrated attempts at gratification, such as this one, represents a set of reality constraints. As the infant grows older and ego development increases, she will realize that she cannot obtain her goal immediately and directly. She must delay gratification until someone opens the door for her, or brings the rattle to her. The ego functions to motivate the individual to delay gratification of impulses, and to explore alternative routes to need satisfaction.

The third component of personality, the **superego,** is often equated with conscience. The superego does not develop until four or five years of age, Freud held, when children begin to *internalize* parental standards of what is good and what is evil. The superego consists of an internalized code of morality that is capable of exerting control over behavior. It serves to keep the id in check by inhibiting antisocial and destructive impulses, and it attempts to channel the functioning of the ego along moralistic lines.

The major *conflict* in personality, according to Freud, is that between superego and id, with the ego serving as a moderator of this conflict. A well-adjusted personality is not one that is free from conflict, but one in which the forces of id, ego, and superego are in equilibrium. As Shaffer (1979) notes:

> The mature, healthy personality is best described as a dynamic set of checks and balances: the id communicates basic needs; the ego attempts to restrain the impulsive id long enough to find realistic methods of satisfying these needs; and the superego decides whether the ego's problem-solving strategies are morally acceptable. The ego is clearly "in the middle" and must serve two harsh masters by striking a balance between what often prove to be opposing demands from the id and superego (p. 28).

Mental Awareness

In addition to the three components of personality—id, ego, superego—Freud hypothesized three areas of the mind: the *unconscious,* the *preconscious,* and the *conscious.* According to Freud, the **unconscious** part of the mind contains unacceptable id impulses and desires, and information that has been "buried" by the ego because it would produce intolerable guilt and anxiety if allowed to reach a conscious level of awareness. We cannot recall information from the unconscious part of the mind except under special circumstances, such as during hypnotic or drug-induced states, or in dreams. Yet the unconscious mind plays an important role in directing behavior and shaping personality. The **preconscious** part of the mind houses information that may be temporarily forgotten, but can be recalled. The **conscious** part of the mind is concerned with immediate perceptions and things we can recall with no difficulty.

Anxiety and the Ego Defense Mechanisms

Freud believed that the contents of the unconscious mind continually seek expression, and that this tendency could result in *neurotic anxiety.* Neurotic anxiety is experienced when id impulses threaten to overcome the ego. Another source of anxiety is the conflict between the superego and one's actions, fantasies, or intentions; Freud called the resulting feelings of guilt *moral anxiety.* Freud distinguished neurotic anxiety and moral anxiety from reality anxiety. *Reality anxiety* is fear that is aroused from realistic threats or dangers associated with the environment. For example, being in the midst of a war could produce a good deal of anxiety that is well justified by the circumstances.

The ego counters anxiety with various defensive measures, including *irrational* ones called **ego defense mechanisms** (Table 19.2). The ego defense mechanisms may be effective in reducing anxiety, but they work in an unrealistic way. They tend to distort reality in order to protect the individual from psychological harm. Consider the defense mechanism called **rationalization,** which involves supplying reasons and justifications for taking a particular course of action while ignoring or denying potentially threatening or unacceptable reasoning that may have more of a basis in reality. For example, a student fails a multiple-choice exam that he did not study for and then complains to the professor that the exam questions were picky and unfair. The student does not entertain the distinct possibility that his

TABLE 19.2 Some Freudian Ego-Defense Mechanisms

Denial	Assertion that some feeling, thought, or event is not unpleasant or discomforting, when in reality it is
Displacement	Redirection of threatening feelings, particularly hostility, toward an object or person not directly responsible for eliciting such feelings
Fantasy	Unrealistic or improbable thoughts designed to compensate for feelings of frustration or inadequacy
Intellectualization	Focus on intellectual aspects of threatening events or circumstances, with corresponding avoidance of the emotional components involved
Projection	Attribution of threatening thoughts, motivations, and feelings of one's own to other persons or objects
Rationalization	Justification of actions by supplying logical or socially approved reasons while ignoring or denying potentially threatening or unacceptable reasons
Reaction Formation	Development of thoughts and actions that belie unconscious motivations
Regression	Return to earlier developmental levels and modes of acting in order to reduce stress
Sublimation	Redirection of unacceptable unconscious impulses to socially approved roles or circumstances

lack of preparation for the exam would have guaranteed failure on any reasonable test of the material. Neither does he consider the fact that others performed exceptionally well on the exam. Thus his excuse making is based on faulty reasoning; though it may temporarily assuage his agitation and feelings of inadequacy, it is a rationalization.

Psychosexual Stages of Development

As we have mentioned, Freud believed that the id, ego, and superego emerge at different times during the child's development. He also thought that the way the id attempts to gratify libidinous impulses differs depending on the developmental stage of the child. Freud proposed five stages of development: *oral* (birth to one and a half years), *anal* (one and a half to three years), *phallic* (three to five and a half years), *latency* (five and a half to twelve years), and *genital* (adolescence). Table 19.3 highlights the major characteristics of each stage. Experiences during the first three stages in particular are crucial for determining later personality, according to Freud.

During the **oral stage** the libido is focused on the mouth and on oral activities in general. Thus tension-reduction and pleasure result mainly from oral stimulation during this stage. Freud designated two phases of the oral stage—the *oral-incorporative* and the *oral-aggressive* phases. During the oral-incorporative phase the motivation is to passively receive stimulation, especially the mother's breast. During the oral-aggressive phase the child has a more active tendency to suck, mouth, bite, and use other means, such as babbling, to obtain oral gratification.

TABLE 19.3 Freudian Stages of Psychosexual Development

Stage	Age	Major Characteristics
Oral	Birth to one and a half years	Libido focuses upon oral region of body. Tension reduction occurs mainly through mouthing, sucking, and biting.
Anal	One and a half to three years	Libido focuses upon anal region. Tension reduction occurs mainly through elimination or retention of feces.
Phallic	Three to five and a half years	Libido focuses upon genital region. Tension reduction occurs mainly through genital manipulation. Oedipal conflict surfaces.
Latency	Five and a half to eleven years	Libido is repressed. Academic and athletic activities predominate.
Genital	Adolescence	Libido resurfaces. Attempts to achieve independence and establish a mating bond predominate.

Too little or too much oral gratification during infancy can lead to an oral **fixation,** according to Freud. Fixations can occur in any of the first three stages if gratification of id impulses has been either too restricted or too excessive. A fixation implies continuous preoccupation with the particular means of obtaining pleasure associated with a given stage, long after the child normally would have passed to another stage. To be fixated orally is to continue to invest a good deal of energy in oral activities, even as an adult. Freud reasoned that a person who received too little oral gratification during infancy would then try to compensate for the oral deprivation by continuing to strive for oral gratification. On the other hand, if someone were orally overindulged during infancy, then that person would want to continue engaging in oral activities because they had been so successful in producing pleasure and security in the past.

Freud believed that oral fixations could take on many different behavioral forms during adulthood, ranging from a preference for oral-genital sex to compulsive smoking or drinking. An adult oral personality resulting from *too little* oral gratification during infancy might include pessimism, suspiciousness, self-depreciation, and envy. Oral personality traits produced by *excessive* oral gratification might include optimism, gullibility, an inflated sense of self-confidence, and a tendency to be manipulative.

During the **anal stage** the focus of the libido is on the anus and anal activities. Freud believed that children achieve great satisfaction in the anal stimulation associated with expelling their feces. This proposal of Freud's is one that was regarded as disgusting and unreasonable by many when his work first came to public notice.

> In a society that assigned functions of the anus to the outhouse, that gagged at the sight or smell of the products of the anus, it must have been ghastly to think that a physician, like Freud, suggested that this dirty area could be the most intense source of pleasure for children ages 18 months to three years. . . . many people still find it difficult to imagine that their anuses can be a source of sensuous satisfaction. In the privacy of their bathrooms, however, many people can admit to themselves that the releasing of the anus can be the real "pause that refreshes." As one of my constipated patients said, it is his most pleasurable time of the month (Prochaska, 1979, p. 29).

As with the oral stage, restrictive or excessive anal experiences can produce fixations. For example, toilet training procedures that are too demanding can produce a fixation that results in *anal-retentiveness,* a motivation to "hold on." This can result in a variety of personality traits manifested in adulthood, as Prochaska explains:

> The child's unarticulated experience appears to have been a sense of having been forced to let go when the child didn't want to let go. Then when the child did let go, what did the parents do with the present to them — just flushed it down the toilet. Now such individuals react as if they will be damned before they again let go against their will. So these personalities hold tightly to money (stinginess), hold onto their feelings (constrictedness), and hold tightly to their own way (stubbornness). In the process of harsh toilet training, however, such people also learn that they are punished if they are not really clean or meticulous, if they are not punctual and orderly about where they go, and if they do not handle their affairs precisely (p. 30).

Freud also argued that children whose parents are permissive in toileting expectations and training run the risk of developing an *anal-expulsive* fixation, the opposite of the anal-retentive. Personality traits attributed to this kind of fixation include extravagant spending habits, wastefulness, explosive expression of feelings, and willingness to be manipulated by others. Moreover, these people may be unstructured, unorderly, and unable to handle their affairs in a precise and efficient manner.

During the **phallic** stage the focus of the libido is on the child's genitals; the greatest satisfaction of id impulses comes from exploration and manipulation of the genitals. This stage is sometimes called the *Oedipal* stage, referring to a major and highly significant sexual conflict that takes place between the ages of three and five and a half years. Freud believed that a boy of this age experiences sexual desire for his mother that is a natural outcome of the fact that his mother has been the primary source of need gratification in the past. The **Oedipal conflict** arises because the father already occupies the niche that the son so eagerly desires. According to Freud, the child experiences a great deal of anxiety over the perceived rivalry with his father, afraid that father might actually castrate him if he were to become aware of the boy's hidden desires. The conflict is normally resolved when the boy represses his desire for his mother and hostility toward his father, and identifies with his father in order to alleviate anxiety. In a sense, the Oedipal conflict motivates same-sex identification in the child.

Freud believed that the Oedipal situation was similar for girls, in that they experience sexual desire for their fathers. However, the reasons Freud gives for this and for the ensuing conflict are not as straightforward as they are for boys. Freud believed that girls experience **penis envy;** that is, they feel cheated that they do not have a penis. A girl directs her hostility toward her mother and longs to be with her father in order to share his unique "possession." Again, the normal resolution of this conflict involves repression of the girl's hostility toward her mother and desire for her father, and identification with her mother.

Fixation in the phallic stage can be brought about by parental permissiveness or harshness in dealing with the child's manifestations of love for the opposite-sex parent, according to Freud. He associated parental permissiveness during the phallic stage with vanity, pride, extroversion, and flirtation and parental harshness with poor self-concept, introversion, and shyness. Freud traced nearly all **neuroses**—behavior disorders characterized by a great deal of anxiety—to failures of the ego in repressing fantasies, desires, anxieties, and hostilities associated with Oedipal conflicts.

The last two stages of Freud's developmental theory differ markedly in character from the first two. During the **latency stage** the libido is not focused on any particular part of the body; rather, it is dormant. The child in this stage is preoccupied with academics, sports, and other school-related activities.

During the **genital stage** the libido is reawakened, but is focused primarily upon heterosexual relationships rather than upon a part of one's own body. This is not to say that id impulses cannot be gratified by self-indulgence, but the primary target of gratification is intimacy with a person of the opposite sex. Reaching the genital stage requires that all has gone "normally" up to this point—no serious fixations, proper sexual identification, and strong ego functioning. The genital stage represents the ultimate level of personality development and integration, and is not reached by everyone, according to Freud.

Evaluation of Freud's Theory

Classical Freudian theory has encountered criticism since its inception. Scientifically speaking, in certain areas the theory appears weak. First, Freud theorized about normal personality from observations of abnormal behavior, mainly clinical observations of women suffering from hysteria. In other words, Freud's data base for the theory was quite limited. Related to this is the problem of inferring personality dynamics based *only* on the *introspections* of patients and Freud's own self-examination. Sole reliance on such methods leaves room for a good deal of subjectivity and possible bias. Finally, many psychologists argue that Freud's theory contains vague, overly complex, and all-encompassing concepts and explanations that are difficult or impossible to disprove or verify empirically.

> Freud provides an explanation for almost all human enterprises. . . . Every idiosyncratic act may be explained within his system. For example, cigarette smoking seems an obvious manner of gratifying oral impulses. It may, however, be anal: a person deposits wastes in a receptacle and excretes (exhales smoke). Furthermore, the part of the cigarette from which the ashes grow is called the butt. The logic of such extrapolations is that excretions involve the depositing of wastes; smoking involves the depositing of wastes; therefore smoking and excretion are related, i.e., smoking is excretion. This form of logic is called assertion of the predicate. . . . Most scientists are less than comfortable with such an exposition and would prefer empirical evidence—reliable data that could not be explained by alternative hypotheses (Ullman & Krasner, 1975, p. 172).

Yet although there are definitely problems with Freudian theory, and few psychologists accept it in its entirety, we should not overlook the significant contributions it has made. Freud gave us the concept of *unconscious* motivation, which revolutionized previous conceptions of normal and abnormal behavior. And even though the unconscious is difficult to study empirically, cognitive psychologists have garnered indirect evidence that implicates unconscious mental activities in a variety of cognitive endeavors (Coleman, 1985; Klatzky, 1984).

Freud also emphasized the importance of experience during the first five or six years of life in shaping personality. Clearly this Freudian emphasis has stimulated a good deal of research and additional theorizing concerned with personal and social development in infancy and early childhood.

Adler and Jung

Alfred Adler (1870–1937) and Carl G. Jung (1875–1961) were two of Freud's early associates, but broke away from the "master" and went on to develop their own views of psychoanalytic personality theory. Adler, like Freud, was a Viennese physician. While a member of the Vienna Psycho-Analytical Society, Adler developed views on psychoanalytic theory that ultimately could not be reconciled with classical Freudian theory. Adler and Freud split in 1911 over their differences, and Adler went on to articulate and develop his own version of psychoanalytic theory.

Although Adler accepted Freud's general notion of the unconscious and its importance in structuring personality, he did not agree that *sexual* motivation was the only, or basic, drive. Adler's early views included the notion that people are driven by feelings of inferiority to compensate and become *superior*. Later, he believed striving for superiority over others to be an immature, neurotic tendency. The healthy personality is innately motivated to adapt to and integrate with others, to become a *social* being, and to become the most "complete" individual he or she can be. Unlike Freud, Adler emphasized the social environment and social nature of man. And where Freud had viewed personality as *determined* by past experience and unconscious irrational forces, Adler maintained that people have a certain amount of *freedom* to direct the course of their development. For Adler, personality is best understood as a creative response to goals and aspirations, rather than as a determined product of biological and environmental forces acting during early childhood.

Carl Jung was an established Swiss psychiatrist prior to his association with Freud. Jung became close friends with Freud and Freud hoped that Jung would one day assume leadership of the psychoanalytic movement. Their eventual separation had a severe emotional impact on both men. The basic difference between Jung and Freud involved the nature of libido. Jung rejected Freud's early notion that libido was entirely sexual in nature. Jung proposed that libido was a very *general* psychic energy that took different forms during development. Jung made his views known to Freud in 1911, and in 1914 formally left the Freudian camp by resigning his position as president of the International Psycho-Analytical Society.

Like Adler, Jung emphasized goals and aspirations as major influences on personality, and gave a greater role to *conscious* aspects of personality than did Freud. Jung was the first to propose that there are two extreme personality types — **introverts** and **extroverts.** These types were characterized in terms of the focus of the libido. For introverts the libido is directed inward, and for extroverts it is directed toward objects and other people. Introverts obtain gratification mainly from their own resources, while extroverts depend primarily on others for satisfaction. Jung also extended and elaborated Freud's "areas of the mind." According to Jung, there are conscious and unconscious aspects to personality. Within the *conscious* realm are the persona and the ego. The **persona** is the outward manifestation of personality, the image one projects to others; it is a mediator between the external world and the other aspects of personality. The *ego* lies at a deeper, though still conscious, level of personality. The ego is the conscious identity an individual has about him- or herself. The persona can be at odds with the ego, as when we project an image to others that we know is false, or at least is not what we think our true self to be.

The unconscious part of personality includes the personal unconscious and the collective unconscious. The **personal unconscious** contains repressed wishes, fantasies, and urges, or otherwise forgotten material. The **collective unconscious** includes experiences that are not unique to an individual, but are common to all humanity. The collective unconscious is made up of **archetypes,** which are inherited tendencies or predispositions to think or act in certain ways that are *universal* among humans. According to Jung, archetypes are *inherited* from our ancestors and are responsible for certain symbols, concepts, and myths common to different cultures.

Jung attached a great deal of significance to the collective unconscious, and by doing so clearly differentiated his thinking from that of Freud or any other personality theorist. Jung believed that healthy personality adjustment could occur only if individuals stopped ignoring or denying the unconscious aspects of their personalities. Slavish conformity to the immediate demands of the ego led to pathology. On the other hand, understanding and accepting the various aspects of personality would result in a unified and stable self.

Other Psychoanalytic Theorists

Adler and Jung placed less emphasis on sexual motivation than did Freud, and more on the ego and the impact of social and cultural factors on personality. Many other so-called neo-Freudians developed views of personality that also emphasized the ego and social influences. Among them are Freud's daughter Anna Freud, Erich Fromm, Karen Horney, Harry Stack Sullivan, and Erik Erikson.

Erik Erikson is especially noteworthy because his developmental theory of personality has stimulated a good deal of research and has been quite popular for some time. Erikson proposed a theory that parallels Freud's stage theory of psychosexual development, but there are several important differences. First, Erikson's stages go beyond adolescence to encompass the entire life span. Also, Erikson emphasizes that people other than the immediate family can and do shape personality in a significant way. Finally, Erikson seems to allow for the possibility of reversing developmental outcomes during later stages.

Erikson's stages are characterized in terms of major problems or crises that can lead to opposite developmental outcomes, depending on the way the individual interacts with the social environment. Table 19.4 gives the major characteristics of each of Erikson's stages; compare it with the Freudian psychosexual stages in Table 19.3.

TABLE 19.4 Erikson's Stages of Psychosocial Development

Zone	Age	Stage (Conflict)
Oral	Birth to one and a half years	Basic trust versus mistrust
Anal	One and a half to three years	Autonomy versus shame
Genital	Three to five and a half years	Initiative versus guilt
	Five and a half to eleven years	Industry versus inferiority
	Adolescence	Identity versus role confusion
	Young adulthood	Intimacy versus isolation
	Adulthood	Generativity versus stagnation
	Maturity	Ego integrity versus despair

The same scientific criticisms that were made of Freud—vagueness, lack of parsimony, and problems with testability—have been leveled at the theories of Adler, Jung, and other neo-Freudians.

Learning Theories

Learning theories of personality are based upon principles of classical conditioning, instrumental learning, and observational learning. They differ from other theories of personality in a number of ways. Most important, learning theories generally characterize personality in terms of *overt behavior,* rather than in terms of inner events such as unconscious motivation or conscious self-awareness. In addition, learning theories focus almost entirely on the *processes* that influence personality, rather than on the structures of personality. Learning theorists emphasize *external environmental influences* on personality and tend to ignore physiological or genetic factors. And finally, learning theorists are generally more concerned with conventional and *rigorous scientific evaluation* of their ideas than are many other personality theorists.

Neo-Hullian Theory

Clark Hull formulated the most elaborate, systematic, and ambitious theory of learning ever proposed. In fact, Hull believed his theory could explain not only learning, but *all* behavior. Hull did not theorize about personality in particular, but some of his contemporaries and followers did. Most notable among this group were psychologist Neal Miller and sociologist John Dollard, who applied some of the basic Hullian principles to the concept of personality (Dollard & Miller, 1950; Miller & Dollard, 1941). It is interesting that both Dollard and Miller had been trained in psychoanalysis; their approach to personality was an attempt to provide an explanation for personality that was more scientific than Freud's, and that was grounded in the experimental psychology of learning.

According to Dollard and Miller, personality can best be understood as a set of "habits"—learned stimulus-response associations. Individual differences in personality are due to different sets of habits. A modified version of Hull's "drive" concept of motivation, and its relation to learning, occupied a central position in Dollard and Miller's account of personality. According to them, people are motivated to acquire habits because of *drives*—energizing stimuli that can arise because of an unmet need or a disruption in homeostasis caused by any intense stimulus (see Chapter 10). The function of drives is to arouse the individual to do whatever is required to *reduce* the drive and thereby fulfill the need and restore homeostasis. Like Hull, Dollard and Miller saw drive reduction as equivalent to reinforcement. In their view, stimulus-response associations that are consistently followed by drive reduction are reinforced, and will become an established part of an individual's personality.

Contemporary Learning Theories

Hull's theory of learning stimulated a great deal of research into basic learning processes. However, what began as a grandiose theory of *all* behavior became, even in Hull's estimation, restricted to explaining mainly maze learning in laboratory rats (Hull, 1952). And many of the particulars of the theory were shown to be wrong, even about learning in rats. Consequently, the Hullian system as a whole was replaced with simpler and better-supported theories. As a result, the Dollard-Miller application of Hull's ideas to personality has been overshadowed by other views, most notably those of Skinner and his associates, and of Bandura.

Both Skinner and Bandura accept the Dollard-Miller theory's general premise that personality consists of responses that have been learned, but Bandura places much less emphasis on motivational drives, and Skinner sees no need to address the concept of motivation at all. There are other important differences between a Skinnerian view of personality and Bandura's ideas. First, Skinner is much more behavioristic than Bandura. His focus is exclusively on *overt* behavior, while Bandura is concerned with inner cognitive events such as attention, memory, and expectations as mediators of behavior. Second, Skinnerians generally believe that responses must be reinforced in order to be learned, but Bandura holds that many aspects of personality are a result of people *imitating* what they have observed, that observational learning can occur without the presence of a reinforcing stimulus. Skinner's notions of instrumental learning (operant conditioning), and Bandura's concept of observational learning were reviewed in Chapter 8.

Evaluation of Learning Theories of Personality

The basic principles of conditioning and learning derived from laboratory investigations are extended to the area of personality by learning theorists. The extensive research support for these theories is quite attractive to many psychologists who study personality, especially when contrasted with the relatively meager data base for psychoanalytic and humanistic-existential theories (which are discussed in the next section). In addition, the focus of Skinnerian theorists on overt behavior and the use of rigorous experimentation to test learning theory provide a degree of objectivity not found in most other theoretical camps.

Critics point out, however, that the strengths of learning theories necessarily entail certain weaknesses. For example, the extensive research base for learning theories consists mainly of animal studies, and these studies have focused on basic learning processes rather than on the relation between those processes and personality. In addition, there are very few *naturalistic* or *longitudinal* studies relating the development of various aspects of personality to the reinforcement or modeling experiences of the individual; the vast majority of learning research bearing on personality consists of short-term laboratory experimental studies. It is not clear whether results from such studies tell us about the actual forces that affect personality in nonlaboratory settings over the lifetime of an individual.

The Skinnerian emphasis on overt behavior seems to preclude attending to the *inner* cognitive and emotional structure and functions of personality, and this is a major point of contention for psychoanalytic and humanistic-existential theorists. However, Bandura and some other learning theorists (for example, Mischel, 1979; Rotter, 1966) consider cognitive processes to be important influences on personality.

Finally, learning theories tend to minimize or ignore the influence of biological factors on personality. Of course, it is easier to directly observe the effects of the external environment on personality than it is to identify internal physiological or evolutionary and genetic influences. Nevertheless, ignoring biological influences will not make them go away. Given the increasing evidence of biological influence on learning, even on human learning (see Chapters 7 and 8), it would seem that learning theories of personality could be enriched by incorporating biological influences into their structure.

Some characteristics of personality may be influenced by observational learning.

Humanistic and Existential Theories

Humanistic and existential theories of personality focus upon the *conscious* elements of personality, and in this regard are more akin to neo-Freudian theories than to Freudian theory. They also emphasize individual *uniqueness* and *freedom* of choice more than other personality theories.

Humanistic Theories

Humanistic theorists emphasize that we are *innately* motivated to strive for what they call **self-actualization,** the tendency to develop our potentials in ways that "maintain or enhance the organism" (Rogers, 1959). You will recognize that this is quite similar to Alfred Adler's notion that we strive to be the most complete individuals we can become. Adler's influence is also seen in many other emphases of humanistic theories—conscious experience, individual uniqueness, and individual freedom.

Humanistic theories have been characterized as the "third force" in psychology, the first two forces being psychoanalytic theory and behavioristic learning theory. Essentially, the humanistic position is a reaction against Freud's view of humans as creatures driven by irrational, hedonistic forces from within. Moreover, humanistic psychologists reject both the Freudian and behavioristic emphases on *determination,* the idea that our personalities are structured by forces over which we have little or no control. They take special issue with the stimulus-response model of behavioristic learning theory. They find it to be overly restrictive, in that it focuses upon the *external* behavior of individuals and ignores the world of subjective perceptions and experiences.

Carl Rogers has been a leading proponent of humanistic psychology for over thirty years, especially its application to psychotherapy. For Rogers, the most important aspect of personality is the *self,* the conscious part of personality that is concerned with thinking, feeling, and making judgments. He is especially concerned with thoughts, feelings, and judgments that are directed inward to form our self-awareness and self-concept. Self-concept, an idea of who we are, is based upon self-awareness—perceptions of ourselves in relation to others. These perceptions are influenced by how others react toward us. If parents and other significant people in our lives provide us with love that is *unconditional,* then we will develop a healthy unconditional positive regard for ourselves.

Rogers, like other humanistic psychologists, believes that our most basic motivation is to maintain and actualize the self. But this striving for self-actualization can be impeded if we do not accept ourselves for what we are, or if we value ourselves only when we do things that have been approved by our parents or other significant persons in our lives. We will have more to say about Rogers's views in Chapters 21 and 22.

Abraham Maslow (1908–1970) is perhaps best known for his proposed hierarchy of human needs and his descriptive accounts of what it means to be a self-actualized person (Figure 19.1). According to Maslow, the most basic needs are physiological in nature, and must be satisfied before needs higher up in the hierarchy can be attended to. Needs for oxygen, food, water, and sex are examples of basic needs. Next in the hierarchy is a need for *safety* from physical danger.

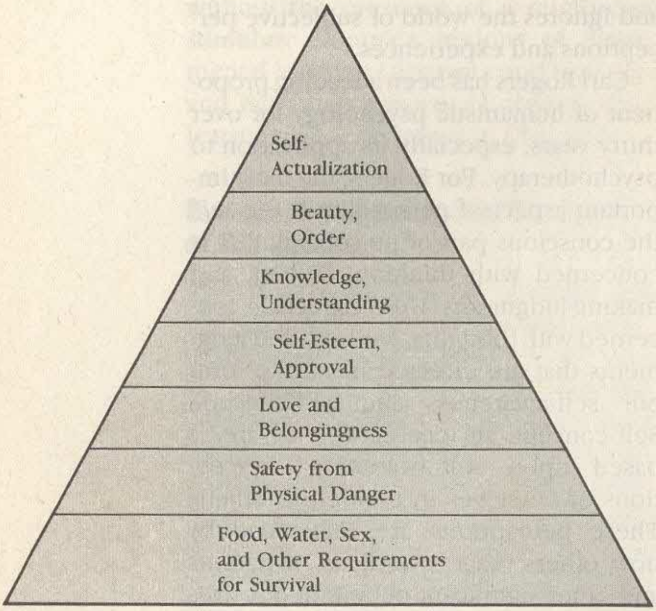


FIGURE 19.1 Maslow's hierarchy of needs.

Then, as we progress through the hierarchy, there are needs for *love and belongingness,* needs for *self-esteem* and *approval from others,* and finally the need for *self-actualization.* Maslow believed that self-actualization would not be a pressing urge unless all other needs in the hierarchy had been satisfied, and he thought that relatively few people ever become completely self-actualized because most are still preoccupied with fulfilling needs at lower levels.

Existential Theories

There are many similarities between existential and humanistic theories of personality. However, many existential psychologists seem to place greater emphasis on individual freedom and responsibility, and some do not take the positive view of human nature espoused by the humanists. While humanistic psychologists place the highest value on self-actualization, many existential psychologists value authenticity as the best form of existence. *Authenticity* means openness and honesty with self and others; awareness and acceptance of self, others, and the human condition; and a harmonious integration of nature, others, and ourselves.

Unlike the humanistic psychologists, existentialists do not argue that we have an innate drive to achieve authenticity. If we are to become authentic, we must *choose* to do so in the face of *existential anxiety.* Becoming an authentic person entails opening ourselves to some potentially terrifying aspects of existence, including the realization that we must die, that there are some events in life over which we have little or no control, and that we can make choices and therefore are responsible for much of our destiny. Other conditions that can produce existential anxiety are the threat of meaninglessness in life and the threat of being alone or isolated from others. An authentic person is one who is aware of all these things, and chooses to *experience* and *confront* existential anxiety rather than avoid it.

Evaluation of Humanistic and Existential Theories

Humanistic and existential theories of personality, although influenced heavily by psychoanalytic theories, are clearly a departure from them, especially from Freudian theory. They are also quite different in both nature and focus from learning theories of personality. Humanistic and existential theorists emphasize the *present, conscious* experiences of individuals and their *subjective* interpretations of these experiences rather than past determinants, unconscious elements, or objective assessments of behavior. Psychoanalytic theorists argue that the humanistic-existential focus is too narrow because it ignores the unconscious mind and developmental events, which can make lasting impressions on the personality. Learning theorists find the extreme subjectivity of the humanistic-existential orientation a serious impediment to arriving at unbiased and accurate conclusions regarding personality. In addition, humanistic-existential concepts are difficult or impossible to test in a conventional scientific manner.

In spite of these criticisms, humanistic and existential theorists have reawakened interest in conscious cognitive and emotional influences on personality, and in the roles of self-awareness and personal choice in structuring personality. Although some critics have considered these psychologists antiscientific, this seems not to be the case. Carl Rogers, for example, has conducted considerable research into processes that influence self-awareness and self-concept. And many of the existential psychologists are committed to the value of researching their propositions, although their views of scientific research as applied to humans represent a considerable departure from those of mainstream psychologists (Valle & King, 1978).

Assessment of Personality

As we have seen, personality has many facets, and this makes objective assessment a difficult prospect. Nevertheless, psychologists have devoted considerable effort to designing procedures and tests for the purpose of classifying various aspects of personality. What follows is a brief sketch of some of the major assessment tools in use today.

Interviews

Interviews vary in structure and content. Some are highly structured, consisting of a set of "canned" questions that are asked of everyone being interviewed. Others are open-ended; the interviewer adjusts questions and comments to the person being interviewed. Clinical interviews often include both dimensions, with some clinicians advising that the interviewer begin with minimal structure and increase structure as the interview progresses (Maloney & Ward, 1976).

Interviews can provide a wealth of information about an individual, information that may go undetected by other assessment procedures, such as tests or direct observations of behavior. A skilled interviewer may be able to learn a great deal about a person's self-concept, psychological strengths and weaknesses, and potential for change.

Clinical interviews can provide a great deal of information about a person. They can also be used to establish a feeling of rapport between client and therapist, as may be happening here.

However, there are some definite drawbacks associated with interviews. Because they vary in structure, it is difficult to gain objective information. For example, the same person may be assessed quite differently by different examiners, or even by the same examiner at different times. Thus the interview method is often *unreliable.* In addition, there is no agreed-upon way to *quantify* the content of interviews, and this lack of precision is unacceptable to many clinicians and researchers.

Finally, personal characteristics of the interviewer and the person being interviewed may interfere with objectivity. Interviewers may have preconceived notions and stereotypes that affect the conduct and outcome of the interviews. For example, a male interviewer may feel strongly attracted to young, outgoing females with blond hair and blue eyes. This kind of weakness could color entire interviews, resulting in the interviewer overlooking certain personality characteristics and reading in others where they do not in fact exist. In addition, there is no guarantee that the interviewees are telling the truth, remember the truth, or are aware of their actual feelings. Thus it is clear that there are a number of reasons why interviews should not be the *only* procedures used in assessing an individual's personality.

The Case History

Taking a **case history** is a procedure used in a clinical situation for gaining historical information about a person. Such information may be crucial for understanding the nature, developmental origins, and duration of an individual's problems. It may also help in determining which therapeutic procedures are most likely to be of benefit.

The autobiographical part of the case history is typically obtained during the interview. But self-reports of past events may be distorted and biased, and therefore it is essential to supplement the autobiographical account with biographical data. Biographical material could include information from the parents, siblings, relatives, spouse, children, employers, and associates of the person under study. Variables of interest in the case history might include geographical location and socioeconomic status of the person's parents; number and order of siblings; important persons in the individual's home or school environment; evaluations of the home atmosphere by those in a position to know; health history; teacher evaluations of school performance, related activities, and emotional stability; and others' assessments of the person's relationships with family, spouse, children, friends, employees, and co-workers.

Tests of Personality

Interviews and case histories are extremely important devices for obtaining information about a person. But they are subject to a good deal of bias on the part of the person being assessed and on the part of those who conduct the interview or participate in the case history. There are, however, more objective tools for assessing personality — personality inventories, projective techniques, and direct observation of behavior.

Personality Inventories **Personality inventories** are "paper and pencil" tests usually consisting of items that describe various personal characteristics. Typically, people taking this kind of test rate each item as it applies to themselves. That is, they determine whether the item is an accurate description of their own perceived personality characteristics.

In constructing personality inventories, careful attention is paid to two characteristics — reliability and validity. A test that is **reliable** is one that is consistent. One index of test reliability is the correlation between repeated administrations of the same test on the same individuals. If the test-retest correlation is high, then the test is considered reliable. A test that is **valid** is one that measures what it was designed to measure. A test that was designed to measure introversion but instead detected some other trait would not be valid. The concepts of reliability and validity are discussed in greater detail in the next chapter.

Most personality inventories, like many other tests, are *standardized* by administering the test to a group of people representing a population of interest. This group is referred to as the standardization or normative group. All those who take the test subsequently will be compared with the **normative group** in order to determine their personality profile. So what personality inventories assess is not an absolute measure of a trait, but whether an individual deviates considerably, slightly, or not at all from the normative group with respect to that trait.

One of the best known, best researched, and most widely used personality tests is the *Minnesota Multiphasic Personality Inventory* (MMPI), designed to detect moderate to extreme deviations from normal personality functioning. The MMPI consists of 550 statements that must be answered "yes," "no," or "cannot say." These statements apply to various aspects of personality and behavior, such as feelings and attitudes related to parents, other people, sex, work, and self.

By observing patterns of response on the MMPI, the examiner can assess many different dimensions of personality. These include depression, paranoia, hysteria, masculinity-femininity, social introversion, and other personality traits or disturbances. There are even ways to detect various response biases, such as the test-taker's attempt to create a good (or bad) impression on the examiner.

The MMPI is often called a *criterion-keyed* measure of personality. A criterion-keyed measure distinguishes between two or more criterion groups, such as those suffering from depression versus those who are introverts. This is accomplished by administering test items to groups that have already been differentiated in some other way. For example, we administer a large number of questionnaire items to a group of individuals diagnosed as depressives, to a group diagnosed as introverts, and to a group of normal individuals. Then we look to see whether there is a characteristic pattern of responding on the test for depressives, a different pattern for introverts, and a third pattern for normal individuals. Those items that clearly distinguish the diagnostic groups from one another, and from normal individuals, are incorporated in the personality inventory; the nondiscriminating items are discarded. Procedures like these were followed in the construction of the MMPI.

The MMPI has proved useful in detecting serious personality disintegration, but it is less successful in assessing personality functioning within the normal range. Other personality inventories, such as the *Minnesota Counseling Inventory* (MCI) and the *California Psychological Inventory* (CPI), are better suited to assessing normal personality variations (Aiken, 1979). Also, the MMPI may yield very different personality profiles depending upon situational factors such as poor health or other kinds of stress, so its results should not be interpreted as reflecting personality characteristics that are fixed and unchangeable.

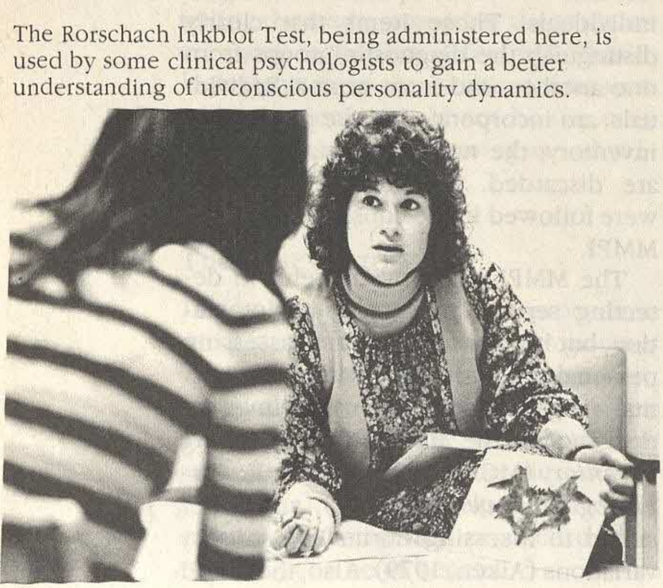
Personality inventories such as the MMPI are assessment techniques that are more objective than interviews or case histories or the projective tests discussed in the next section. Nevertheless, there are considerable problems associated with the construction and interpretations of these inventories (Maloney & Ward, 1976). Because of these problems, and perhaps because many aspects of personality are not stable across different situations, personality inventories are not as reliable as intelligence tests (see Chapter 20), and their validity is more often assumed than demonstrated.

Projective Techniques **Projective tests** of personality consist of relatively unstructured, ambiguous items which the examinee must respond to on the basis of his or her interpretation of the item. The term *projective* is a clue to the rationale underlying these kinds of tests, which is that examinees will reveal hidden motives and tendencies if confronted with ambiguous situations. **Projection** in Freudian psychoanalytic theory is an ego defense mechanism that helps ward off anxiety by ascribing undesirable internal motives or dispositions to others. Projective tests were designed so as to elicit as much projection as possible. It is assumed that the examinee, in responding to the ambiguous items, will unknowingly project aspects of personality lying within the unconscious or preconscious realm, which may not be accessible using more direct methods of assessment.

The projective technique that most people have heard about is the so-called inkblot test. There is more than one such test, but the most widely used is that developed by the Swiss psychiatrist Hermann Rorschach. The **Rorschach test** consists of ten cards displaying inkblots that are presented one at a time to the person taking the test. The examinee is asked what each of the inkblots look like or what it is reminiscent of. The administration of the test is divided into two components: the *performance proper* and the *inquiry*. During the performance proper, the examiner records the examinee's description, the time taken to respond to each inkblot, how the examinee positions the card, and how he or she holds the card when responding. In the inquiry phase, the examiner readministers the inkblots and questions the examinee further to ascertain the reasons for the particular responses given.

The scoring and interpretation of the Rorschach depend upon a fairly detailed and complex analysis of the responses (Klopfer & Davidson, 1962). Interpreta-

The Rorschach Inkblot Test, being administered here, is used by some clinical psychologists to gain a better understanding of unconscious personality dynamics.



tion depends upon patterns of response and recurring themes such as hostility, anxiety, or self-destructive tendencies. Typically, interpretation follows along the lines of psychoanalytic theory.

Another kind of projective technique involves the presentation of pictures that are more meaningful than inkblots, but still ambiguous. The pictures might consist of people or animals in various locations and poses. The task of the examinee is to make up a story about each picture, describing what is taking place, the events that preceded those in the picture, and the imagined outcome or ramifications of the pictured events.

The most widely used test of this kind is the **Thematic Apperception Test (TAT),** which consists of thirty pictures of people in ambiguous situations and one blank picture. A range of scoring and interpretation techniques is available for use with the TAT, but interpretation is generally quite subjective. As Henry Murray, the creator of the TAT, noted in 1943, interpretations of TAT responses should be regarded as *hypotheses,* not as established fact. There are many variations of the TAT; the most notable are versions suitable for children, such as the *Children's Apperception Test* (CAT).

Many clinicians swear by projective techniques such as the Rorschach and the TAT. But it is not easy to establish reliability and validity for projectives in a conventional manner, and the Freudian rationale and flavor of the interpretations of projective test results are not accepted by many other psychodiagnosticians.

Direct Observation of Behavior

Psychologists who adhere to learning theories of personality are emphatic about the need for observing overt behavior as a replacement or supplement for other methods of personality assessment. As far as they are concerned, it is important to know what people actually do, not just what they say they do or what they say they think or feel. Actually, most clinicians of other theoretical bents probably would agree with the need for behavioral observation, although they would not see it as a replacement for other assessment techniques.

Systematic observation of overt behavior allows for a high degree of objectivity, but it is not always a realistic alternative. Usually it is impossible to make such observations in a person's normal environment—at work, at play, or at home. And it is often difficult to get people to come to the clinic and interact with family and friends while they are being observed. Even when this is possible, the artificial setting and the expectations of those being observed may bias the samples of behavior that are recorded.

Stability of Personality

A major controversy about personality concerns the stability of traits and overt behaviors across situations. Do we develop a set of personality characteristics that are unchanging, regardless of the situations in which we find ourselves? Or do our personalities change depending upon the expectations, demands, or contingencies we encounter in different environments?

One of the most outspoken critics of the stability hypothesis has been psychologist Walter Mischel (1968, 1976), who argues that we behave in response to the environment, not as an expression of some fixed internal personality structure. Indeed, when we observe the variability of behavior any given individual displays when faced with different situations, it is hard not to be sympathetic to Mischel's view. Children often act quite differently at home than at school, and people who are congenial with others at work may be hostile or withdrawn when at home with the family. Such variation was documented many years ago in a classic study by Harthshorne and May (1928). These investigators observed children in a number of experimental situations in which the children were tempted to be dishonest. The results showed little consistency in the children's behavior across situations. In other words, children were not basically honest or dishonest under all conditions; their behavior varied according to the situations they found themselves in.

Even though there may be much variation in a person's behavior, however, it would seem unwise to conclude that there is *nothing* stable or consistent about personality. We have already mentioned evidence from longitudinal studies suggesting that certain temperamental characteristics, such as sociability, do appear stable over the years in children. And additional data show that adults rate certain aspects of their personalities as consistent traits, and such traits also tend to be rated as consistent by acquaintances of these individuals (Bem & Allen, 1974). The fact that people vary their behaviors to adjust to different situations does not exclude the possibility that they also retain consistent ways of expressing their personalities.

Supplement 1. Cognitive Dissonance: A Theory of Rationalization

As we saw in the discussion of Freudian theory, rationalization is basically self-justification in response to anxiety, anxiety that Freud thought was generated primarily by unconscious conflicts. Leon Festinger (1957) proposed a theory that specifies the circumstances under which attempts to justify one's actions are likely to occur—the theory of **cognitive dissonance.** However, this theory is not based upon Freud's notion that unconscious conflicts are ultimately responsible for defensive behaviors such as rationalization. Rather, cognitive dissonance theory holds that *inconsistent cognitions* are responsible for attempts at self-justification. Here *cognitions* refers to perceptions of events, including one's own behavior, reflections on past experience, attitudes, beliefs, and opinions.

The basic elements of the theory are straightforward:

1. When one cognition is not logically consistent with another, cognitive dissonance can result.
2. Dissonance produces unwanted tension, which motivates the person to reduce the tension.
3. Dissonant cognitions that are important, or have important consequences, will generate more tension than trivial cognitions.
4. Tension reduction is achieved by changing dissonant cognitions so that they become *consonant* (logically consistent); dissonant cognitions are changed by adding cognitions that are consonant with existing ones, or by avoiding situations that maintain or increase dissonance.

Consider the following example. A university professor who teaches a course in logic conveys to students that he values a "logical mind" more than life itself, and ridicules those who are intuitive or superstitious. Unexplainably, he finds himself strongly attracted to a female student who is an intuitive thinker, tells him that logic stifles creativity, and professes a belief in astrology and the occult.

According to cognitive dissonance theory, the professor is likely to experience unpleasant tension caused by his professed negative attitude toward intuitive, superstitious types on the one hand, and his romantic attraction to a person who manifests these traits on the other. How can he possibly love someone who represents the antithesis of his beliefs? Cognitive dissonance theory would also predict that the professor is likely to change his thoughts or actions, invent new thoughts, or avoid dissonance-arousing situations in order to reduce the tension he experiences. For example, he might decide that opposites attract, so his desire for the student makes perfect sense. Or he might discover and exaggerate those few instances of logic that are shown by the student. Another strategy would be to reevaluate and change his negative attitude toward those who do not reason logically, or at least refrain from conveying these feeling to others.

According to Festinger, cognitive dissonance is almost always involved in decision-making, especially in the aftermath of the decision. A case in point: In the course of writing this textbook, each of the authors on occasion decided to take a break. Of course, we were highly motivated to finish the text and had already devoted a good deal of time and energy to it. So decisions to "escape" from the manuscript were almost guaranteed to produce dissonance: "How can we think or tell people we are really going to finish this thing when we are fishing, hiking, or relaxing at the beach?" Invariably, though, we found ways to reduce our dissonance. One of the more frequent justifications was that it was important to get away from the manuscript in order to "clear our heads" and "come back fresh," "recharge the ol' batteries." The rationalization, of course, was that the quality of the book would suffer if we did not take an occasional break, or that we might "run out of gas" and never complete it.

Cognitive dissonance theory is not restricted to explaining self-justification; it is a general cognitive theory of social behavior, and has been quite popular among social psychologists. In general this popularity seems justified by research results consistent with the theory. However, the original theory has been criticized for ignoring the roles of *volition* and *commitment.* Brehm and Cohen (1962) argued that if one feels free to reverse a decision no dissonance should be experienced, and that the magnitude of dissonance will depend upon how committed one is to one's contradictory cognitions. The research literature on cognitive dissonance suggests that it occurs only if a person feels responsible for producing the inconsistent thoughts or beliefs (Wicklund & Brehm, 1976).

Although the original theory made no allowance for individual differences, some psychologists have expanded cognitive dissonance theory by proposing individual differences in tolerance for dissonance and in ways of reducing tension related to dissonance (Shaw & Costanzo, 1982). One of the psychologists who emphasized individual differences, Elliot Aronson, also proposed a major modification of the theory (1976). Aronson hypothesized that dissonance does not stem from the logical inconsistency between two cognitions. Rather, cognitions or behaviors that are inconsistent with a person's positive self-image, and have harmful consequences for others, are the sources of dissonance. Aronson gave this example:

> . . . Consider Sam, who believes that marijuana is dangerous and should definitely not be legalized. Suppose he is induced to make a speech advocating the use of marijuana . . . to an audience consisting of individuals whom he knows to be irrevocably commited to a position opposing the use of marijuana. . . . In this case, there are no dangerous consequences for the audience, because they are unlikely to be changed by Sam's communication. That is, the communicator is in little danger of doing anyone any real harm. According to our view of dissonance theory, Sam would [experience no dissonance and] not change his attitude, because he is not doing anyone any harm. . . . On the other hand, if Sam were induced to make the identical speech to a group of individuals who have no prior information about marijuana, we expect that he would experience much more dissonance than in the other situation. His cognition that he is a good and decent person is dissonant with his cognition that he has said something he doesn't believe; moreover, his statement is likely to have serious *belief* or *behavioral consequences* for his audience (pp. 110–11).

Supplement 2. Ethnic Differences in Infant Temperament

In Chapter 6 we mentioned that newborn temperament includes such things as activity level, rhythmic pattern, distractibility, approach and withdrawal patterns, responsiveness, adaptability, and mood quality. Thus temperament is intimately related to personality, and may be the first manifestation of personality in infants. This supplement describes some of Daniel Freedman's fascinating observations of temperament in babies of different racial origins (Freedman, 1982). Freedman claims to have found evidence that infant temperamental characteristics can be tied to race. His strong implication is that such differences are due in part to different genetic characteristics among the races studied.

Together with Harvard pediatrician T. Berry Brazelton, Freedman developed a group of tests designed to measure "basic human reactions" in newborns — the Cambridge Behavioral and Neurological Assessment Scales. These scales were a modified version of the Brazelton scale (Brazelton, 1973), with the items divided into five categories: temperament, sensory development, autonomic and central nervous system maturity, motor development, and social interest.

In one study Freedman and his wife Nina compared the responses on the Cambridge Scale of Chinese and Caucasian infants. (Freedman notes that the choice of racial groups was no accident — his wife is Chinese.) The infants included twenty-four newborn Chinese of Cantonese background and twenty-four newborn Caucasians of Northern European background, all tested at the same hospital in San Francisco. For each group there were equal numbers of boys and girls; the kind and amount of drugs received were the same; mothers were the same age and had had approximately the same number of previous children; family health plans, prenatal care, and income levels were similar.

Results of the tests are intriguing, and show clear-cut differences between the two groups. Caucasian babies cried more readily and were harder to console than the Chinese infants. When placed face down in their cribs, Caucasian babies turned their heads to one side immediately, but Chinese infants tended to keep their heads "buried in the sheets," and adapted to almost any position in which they were placed. When the examiner placed a cloth over a baby's nose, Caucasian babies showed a defensive reaction, immediately turning their heads and apparently struggling to remove the cloth. This is a well-documented normal reaction in black as well as Caucasian babies in Western societies. In contrast, the Chinese babies in Freedman's study did not struggle; they continued to lie on their backs, and breathed through their mouths when the cloth was placed over the nose.

These and other findings suggested that the Chinese babies were characteristically more compliant and less irritable than the Caucasians. "It was as if the old stereotypes of the calm, inscrutable Chinese and the excitable, emotionally changeable Caucasian were appearing spontaneously in the first 48 hours of life" (p. 16).

Freedman conducted another similar study involving thirty-six Navaho newborns. The typical Navaho responses were strikingly similar to those of the Chinese newborns, and markedly different from those of the Caucasian babies. What do the Chinese-Navaho similarities in newborn temperament imply? And what about the differences between these groups and Caucasian infants?

Freedman speculates that genetic factors may underlie both the similarities and the differences. There are, in fact, arguments consistent with Freedman's hypothesis. First, all babies tested were newborns. Thus it seems highly unlikely that different postnatal environment factors, such as different mother-infant interactional patterns, could have accounted for the behavioral differences observed. Second, the environments for Chinese and Navaho babies, including prenatal and postnatal factors, are quite dissimilar, yet many of the characteristics of temperament in Chinese and Navaho newborns are quite similar. This could be coincidence. But consider the following:

> Navaho and Chinese newborns may be so much alike because the Navaho were part of a relatively recent emigration from Asia. Their language group is called Athabascan, after a lake in Canada. Although most of the Athabascan immigrants from Asia settled along the Pacific Coast of Canada, the Navaho and Apache contingents went on to their present location in about 1200 A.D. Even today, a significant number of words in Athabascan and Chinese appear to have the same meaning, and if one looks back several thousand years into the written records of Sino-Tibetan, the number of similar words makes clear the common origin of these widely separated peoples (Freedman, 1982, p. 17).

It is important to emphasize that the Navaho and Chinese may have more genes in common with each other than with Caucasians because their separation occurred relatively recently. Freedman makes a case for such an expectation:

> Peking Man, some 500,000 years ago, already had shovel-shaped incisors, as only Orientals and American Indians have today. Modern-looking skulls of about the same age, found in England, lack this grooving on the inside of their upper incisors. Given such evidence, we can surmise that there has been substantial and long-standing isolation of East and West. Further, it is likely that, in addition to just plain "genetic drift" [random genetic differences between populations], environmental demands and biocultural adaptations differed, yielding present-day differences (p. 19).

If Freedman's observations are replicated by others, with special attention paid to assessing prenatal environmental similarities and differences among racial groups, it will be difficult to argue that we are all born the same, regardless of racial background. More important, we can perhaps begin to assess how any observed racial differences or similarities in newborn temperament may interact with child-rearing patterns to produce racial differences or similarities in adult personality.

Intelligence and Intelligence Testing

20

History of Intelligence Testing

The Stanford-Binet IQ Test

The Wechsler Tests

Other Tests of Intelligence

Evaluating Intelligence Tests

The Development of Intelligence

Intellectual Retardation

The Intellectually Gifted

Intelligence and the Nature-Nurture Controversy

Theories of Intelligence

Chapter Preview

The scientific investigation of intelligence and the construction of intelligence tests were stimulated by a concern for understanding *individual differences* in behavior. Attempts to measure individual differences in intelligence began with Sir Francis Galton over a century ago. But it was Alfred Binet, a French physician, who published the first widely accepted test of intelligence. This test was revised and translated into English by Lewis Terman and his associates at Stanford University, and has come to be called the Stanford-Binet. The Stanford-Binet has undergone several revisions and today is one of the most respected individual IQ tests.

Another respected and widely used series of individual IQ tests was developed by David Wechsler—the Wechsler tests. There are also group tests of intelligence that can be administered to more than one person at a time. The *Cognitive Ability Test (CAT)* and the *Scholastic Aptitude Test (SAT)* are popular group tests in use today.

Psychological tests are judged in terms of their *reliability* and *validity*. To be reliable a test must yield consistent results. Three methods for determining the reliability of a test are *test-retest, parallel forms,* and *internal consistency*. In order to be *valid* a test must accurately measure what it was designed to measure. There are three major kinds of test validity: *content validity, criterion validity,* and *construct validity*. A test must be reliable in order to be valid, but high reliability is not a guarantee of validity.

Although IQ is related positively to performance in school, it does not *determine* that performance. The IQ is not a fixed entity. For any individual it can fluctuate, and it may or may not predict academic success accurately.

Early developmental investigations of intelligence indicated that it increases in early childhood, levels off during adolescence, and remains fairly stable until middle age, when it declines. However, more recent research suggests that there can be large fluctuations in the IQ of any individual, and that many cognitive skills show no apparent decline in adulthood.

Intellectual or mental retardation is a developmental disorder characterized by subnormal intelligence test performance and deficits in adaptive behavior. Approximately 2 to 3 percent of the U.S. population is mentally retarded, but in most of these cases the precise causes of retardation are unknown. There is no agreed-upon definition of intellectual giftedness, as there is for mental retardation. Also, relatively little research has been directed toward understanding the gifted.

The nature-nurture controversy has been most pronounced and heated in the area of intelligence and intelligence testing. The most controversial position in recent history was that taken by Arthur Jensen, who asserted that 80 percent of the variation in IQ among individuals is due to hereditary factors. It seems clear that IQ is heritable, but probably not to the extent that Jensen hypothesized.

Following the construction of intelligence tests, several theories were proposed to describe the *structure* of intelligence. Some theorists argued that intelligence is best characterized as a *single, generalized* ability, while others hypothesized that intelligence consists of a number of *different* abilities. Many psychologists today appear to be dissatisfied with traditional theories of intelligence, and have proposed that we try to understand how intelligence *functions,* how it operates in nonacademic environments, and how it is adaptive.

Intelligence testing and theories of intelligence were stimulated by a concern for describing, predicting, and understanding *individual differences* in behavior. Individual differences in physical and behavioral characteristics are not unique to humans; they are spread throughout the animal kingdom. Dominance hierarchies ("pecking orders") are found in many species of mammals and birds, and are established and maintained largely because of individual variations in size, strength, territorial displays, and agonistic behavior such as aggressive postures, grimaces, gestures, or vocalizations. Many animals can discriminate and respond appropriately to these individual differences within their species and, indeed, must do so in many situations in order to survive.

Some level of awareness of individual differences in humans was undoubtedly part of our inheritance from primate ancestors. The earliest recorded evidence of such awareness can be found in the writings of Plato and Aristotle from the fourth century B.C.. But it was not until the nineteenth century that individual variation was observed and documented systematically and the concept of individual differences within a species was given a fundamental position in a scientific theory. This was accomplished by Charles Darwin, who asserted clearly that variation within each species (including humans) was natural, and was in fact essential for natural selection to work. As we saw in Chapter 4, Darwin assumed that such variation was due in part to inherited (genetic) differences among individuals. Darwin's emphasis on individual differences set the stage for attempts to measure and explain such differences.

History of Intelligence Testing

Galton and Cattell

Attempts to measure individual differences in intelligence, or any psychological trait for that matter, began in England with Sir Francis Galton (1822–1911), a half-cousin of Charles Darwin. Ten years after the publication of Darwin's first edition of *On the Origin of Species by Means of Natural Selection,* Galton published a book called *Hereditary Genius* (1869) in which he produced evidence that "eminence" tends to run in families. A person who was a gifted composer or intellectual, for example, would tend to have family members who were also gifted in these or other ways. Others were to show later that mental retardation also tends to run in families (Goddard, 1912).

Galton's observations led him to believe that it was important to identify those who had superior intellectual potential. He devised several assessment tools, including tests of physical strength and reaction time, questionnaires, and introspective analyses related to sensation and perception. Galton believed strongly that individual differences in intelligence and other traits were due mainly to hereditary factors. He advocated human **eugenics**—selective breeding—as the way to improve the lot of humankind, and founded the eugenics movement, which spread to nearly every Western nation during the early 1900s. Scientific curiosity undoubtedly played an important role in stimulating Galton's research on mental tests. However, it is quite likely that Galton's desire to promote interbreeding of "superior" individuals, and to advocate sterilization of the mentally retarded, also influenced his attempt to quantify individual differences in intelligence.

In the United States, James McKeen Cattell (1860–1944), an experimental psychologist who had studied with Wilhelm Wundt in Germany, was also instrumental in the mental testing movement. Cattell was actually the first to introduce the term "mental test" (1890), and he is often referred to as the father of mental testing. Like Galton, Cattell established a battery of simple sensory-motor, perceptual, and memory tests designed to assess various aspects of mental ability. Optimistically, Cattell believed that such tests could be used to diagnose those who were intellectually superior or deficient, and thus could serve as valuable instruments of selection of individuals for various training programs. Cattell's influence in the United States was substantial; he established the area of individual differences as a legitimate field of psychological investigation, one that had important implications for education and industry.

Despite the enthusiasm of Galton and Cattell, their early test batteries were found to be seriously deficient. First, there were problems with *reliability;* the tests did not produce *consistent* results. Second, the tests did not appear to be measuring what they were designed to measure; that is, they were not *valid.* For example, performance on Cattell's tests showed little relationship with academic grades (Wissler, 1901). Although these failures resulted in some initial disillusionment with the testing enterprise, the setback was only temporary. Others, most notably the French physician Alfred Binet, developed more complex tests which overcame the limitations associated with earlier tests.

Binet and the Concept of Mental Age

In 1904 Binet was contracted by the Ministry of Public Education in Paris to construct a screening measure for children entering the public school system. The challenge was to devise an instrument that would identify those who could not profit from a traditional education, such as the mentally retarded. In 1905 Binet, together with Théodore Simon, published the Binet-Simon scale. The scale consisted of several items that Binet thought would tap those skills and areas of information necessary for academic success. In developing the scale, Binet administered many items to children of various ages. He then grouped the items according to age level. For example, "eight-year-old" items were those that 65 to 75 percent of eight-year-old children tested by Binet generally passed.

In 1908 Binet revised the scale and introduced the concept of **mental age (MA).** Mental age was determined by the highest age level at which a child performed on the test. If a child answered all of the "eight-year-old" items correctly, then the child's MA would be eight years, regardless of chronological age (CA). The concept of mental age allowed comparison of children's intellectual performance with that of their same-aged peers.

Binet revised his scale one final time, in 1911, before he died. The scale was translated and distributed around the world, and the practice of expressing scores in terms of mental age became widespread.

The Stanford-Binet IQ Test

In 1916 Lewis Terman and his associates at Stanford University published an English version of the Binet-Simon scale called the Stanford-Binet Intelligence Scale. It was the first time the concept of the **intelligence quotient (IQ),** originated by the German psychologist William Stern, had been incorporated in a mental test. An IQ can be calculated as follows:

$$IQ = MA \div CA \times 100.$$

So if a child has an MA of 8 years and a CA of $6\frac{1}{2}$ years, the IQ score would equal 123. A person with an MA equal to his or her CA will have an IQ of 100; this is considered an *average* IQ. If a person's CA exceeds the MA, the IQ score will be less than 100.

The Stanford-Binet, administered individually, is a widely used test of intelligence.

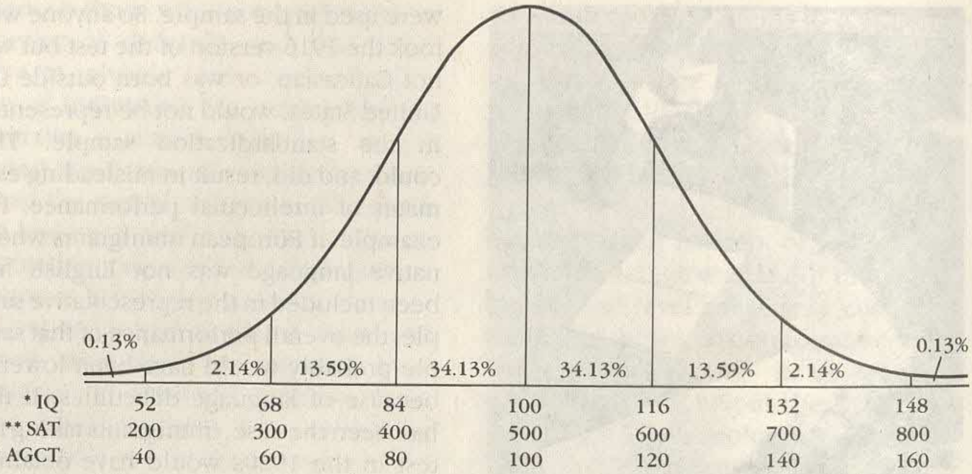
The Stanford-Binet underwent major revisions in 1937, 1960, and 1972. One of the reasons for revising intelligence tests periodically is that some of the test items become outdated. Another reason has to do with the original group of people who took the test, the *normative* or *standardization* group. When an intelligence test is first constructed, it is *standardized* on a *sample* of individuals who are representative of a larger population. For example, the 1916 Stanford-Binet was standardized on a sample of 1,000 children and 400 adults. From 1916 until the 1937 revision, the performance of those taking the Stanford-Binet was compared with that of the 1916 sample in deriving IQ scores.

Unfortunately, the 1916 standardization sample was seriously limited. Only white children born in the United States were used in the sample. So anyone who took the 1916 version of the test but was not Caucasian, or was born outside the United States, would not be represented in the standardization sample. This could, and did, result in misleading estimates of intellectual performance. For example, if European immigrants whose native language was not English had been included in the representative sample, the overall performance of that sample probably would have been lowered because of language difficulties. If this had been the case, immigrants taking the test in the 1920s would have obtained higher IQs than they actually did.

The consequences were sometimes tragic. For instance, during the 1920s and '30s many potential immigrants were declared intellectually incompetent on the basis of IQ test results that were in fact not valid. In some cases the test results were used to prevent these people from becoming legal residents of the United States.

Even carefully selected samples may become less representative of the larger population over the years because of changes in educational curricula, exposure of the population to more information, dating or modification of information, and so on. Therefore it is necessary to revise the norms of the test every so often. The 1972 revision of the Stanford-Binet represents a change in the norms only (a new standardization sample); the items are the same as in the 1960 edition of the test.

Thus intelligence tests may be revised because of deficiencies in the items themselves, or because of a need for establishing new norms. A third reason for revision involves scoring procedures. The 1960 revision of the Stanford-Binet incorporated a major scoring revision—the *deviation IQ*.



* Deviation IQs from the Stanford-Binet Intelligence Test (Standard Deviation = 16)

** Scores from verbal or quantitative subtests of the Scholastic Aptitude Test (Standard Deviation = 100)

*** Scores from the Army General Classification Test (Standard Deviation = 20)

FIGURE 20.1 The relationship of selected intelligence test scores to areas of the normal curve.

The deviation IQ was introduced because of a major limitation associated with the ratio IQ (MA ÷ CA × 100). The abilities that underlie performance on intelligence tests do not increase in a linear fashion with age. Rather, they begin to top out, on the average, during the teenage years. For example, a typical child of nine can successfully complete many more items than an average six-year-old can, but a three-year difference between individuals in their twenties will not translate into a performance difference on the test; in other words, a typical twenty-four-year-old will have no performance advantage over a twenty-one-year-old by virtue of age.

The problem with the ratio IQ is that CA continues to increase, but MA does not, making it an inappropriate measure of adult intelligence. The deviation IQ handles this problem nicely. For any given age group in the standardization sample, the average (mean) *raw score* of the group is assigned an IQ value of 100. Thus, by definition, the mean performance of a given age group equals 100. If an eighteen-year-old college student takes a Stanford-Binet, 1972 edition, and scores the same as the mean of the 1972 eighteen-year-old sample, then the student's IQ score will be 100.

But what if the student's raw score on the test is not the same as the standardization sample's mean raw score? What if the student's score exceeds the mean raw score? The particular IQ that should be assigned is determined according to how far, in *standard deviation* units, the student's raw score is from the mean raw score of the standardization sample.

Recall from Chapter 3 that a standard deviation is a commonly used *measure of variability* of scores in a distribution. More specifically, the standard deviation reflects the average amount of difference between each score in a distribution, and the mean of that distribution. Just as we assigned an IQ of 100 to the *average* raw score of the standardization sample, we can also assign an arbitrary number to the *standard deviation* of the raw scores. For the Stanford-Binet, this number is 16. Let us return to our example of the above-average student. Statistical procedures allow us to determine both the mean and the standard deviation of any set of scores. Suppose we do this for the standardization sample and find that the student's obtained raw score lies one standard deviation above the mean raw score of the sample. By definition, then, our student will receive an IQ score of 116, based on the rule that 16 IQ points equals one raw score standard deviation. If the student had scored one-half standard deviation above the mean, the IQ score assigned would have been 108.

Deviation IQs form a bell-shaped distribution and, because of this, correspond to other indicators of relative standing, such as percentiles (Figure 20.1). As you can see, most people (about 68 percent) have IQs that lie between 84 and 116 (±1 standard deviation from the mean). Scores lying below 84 or above 116 are less frequent in the population. For example, only about 0.13 percent of the population receives IQ scores greater than 148 (3 standard deviations above the mean).

The Wechsler Tests

The Stanford-Binet is one of the two most widely used measures of intelligence; the other is a series of tests devised by David Wechsler. Wechsler, who was working as a psychologist on the staff of Bellevue Hospital in New York, developed an intelligence test for adults—the *Wechsler-Bellevue Scale Form I*—published in 1939. Wechsler added a second form of the test, Form II, in 1947, and revised and restandardized the original form in 1955. This revision, called the *Wechsler Adult Intelligence Scale (WAIS),* was the first intelligence test to use the deviation IQ. Deviation IQs from the WAIS and other Wechsler tests have a standard deviation of 15.

Unlike the Stanford-Binet, the WAIS was designed for adults between sixteen and seventy-five years of age. Also, the test consists of various subtests designed to measure *different* abilities, and the individual receives a score on each subtest. Six of these subtests are classified as *verbal,* and five as *performance* tests. An individual taking the WAIS receives a Verbal IQ, a Performance IQ, and a Full-Scale (overall) IQ. Verbal items are concerned with knowledge of vocabulary, general information, memory, and mea-

This woman is taking the block design (Performance) subtest of the Wechsler Adult Intelligence Scale. In this particular subtest, the designs pictured on each page of a booklet must be matched by arranging blocks, each containing elements of the design. Both accuracy and speed are considered in scoring this subtest.

sures of comprehension and reasoning. Performance items consist of tests of visual-motor coordination, spatial ability, and comprehension of visual-spatial problems.

Wechsler also developed IQ tests for children six to sixteen years of age, the first of which was a downward extension of the Wechsler-Bellevue Scale Form I. This test, published in 1949, was called the *Wechsler Intelligence Scale for Children (WISC).* The WISC was revised in 1974 as the WISC-R. Like the WAIS, the WISC and WISC-R consist of verbal and performance subtests, and are scored in a similar way—Verbal, Performance, and Full-Scale IQs.

Wechsler devised yet another test, the *Wechsler Preschool and Primary Scale of Intelligence (WPPSI),* for testing children between the ages of four and six and a half. It was published in 1967, and is constructed and scored in a manner similar to the other Wechsler scales.

Other Tests of Intelligence

The Stanford-Binet and Wechsler tests are probably the most comprehensive tools for assessing intelligence that are in wide use today. These tests are called *individual* tests because they are administered by an examiner to one person at a time. There are other individual intelligence tests in use, as well as *group* intelligence tests—those that can be administered by an examiner to several people at one time.

Individual Tests

One of the more popular individual tests is the *Peabody Picture Vocabulary Test (PPVT).* The PPVT consists of a series of pictures that are presented to the examinee, four at a time. The person taking the test must point to the picture that corresponds to a word given by the examiner. The PPVT does not require a verbal response, and takes only fifteen to twenty minutes to administer, in contrast to the hour or so required for the Stanford-Binet or Wechsler scales. It is ideally suited to testing young children and individuals with verbal handicaps. Performance on the PPVT is moderately to highly correlated with scores on the Wechsler scales and Stanford-Binet.

Another individual test that does not require verbal responses is the *Leiter International Performance Scale.* The Leiter requires the examinee to select blocks with symbols that match or complete other symbolic patterns, and it is used extensively with speech- and hearing-impaired individuals. This test is sometimes considered a *culture-free* test of intelligence because it is administered nonverbally and does not require verbal responses.

Group Tests

Arthur Otis, a student of Terman's, attempted to adapt some of the Stanford-Binet tests to written form. Many of his adaptations are found in the earliest group intelligence test, the *Army Alpha.* The Army Alpha and a test for those who could not read or write, the *Army Beta,* were developed by the American Psychological Association under the leadership of Robert M. Yerkes. The basic idea was to develop a fairly quick and economical means of identifying intellectual performance. The Army Alpha consisted of verbal and mathematical items, and the Army Beta was nonverbal. These two tests were given to nearly two million U.S. Army soldiers during and after World War I (Aiken, 1979).

During the 1930s Otis and many other psychologists published a number of different group intelligence tests. Most modern group tests consist of various subtests in written form designed to assess different abilities. The format is usually multiple-choice, and actual IQ scores may or may not be assigned. Examples of group intelligence tests that you may be familiar with include the *Cognitive Ability Test (CAT),* the *Army General Classification Test (AGCT),* the *School and College Ability Tests (SCAT),* the *Scholastic Aptitude Test (SAT),* and the *Graduate Record Examination (GRE).* Figure 20.1 shows the relationship between SAT, AGCT, and Stanford-Binet IQ scores.

Evaluating Intelligence Tests

The effectiveness of any psychological test is judged in terms of its reliability and validity. A test is *reliable* if it produces consistent results. A test is *valid* if it measures what it was designed to measure.

Reliability

It is extremely important that a test be reliable, because while it measures only a limited sample of behavior we make inferences based on that sample that are very broad in scope, and that can have significant consequences for the test-taker. In the case of intelligence tests, the examiner estimates the examinee's overall intellectual ability based on perhaps just an hour's testing. That assessment can influence the person's educational or professional placement and the expectations that parents, teachers, supervisors, and others will have, as well as the person's self-image and goals. Obviously, tests that are subject to a great deal of measurement error — that are unreliable — do not operate in the best interests of the test-taker or those charged with making decisions based on test results.

There are three classical methods for determining the reliability of a test: *test-retest, parallel forms,* and *internal consistency.* The most direct estimate of reliability is achieved by correlating the performance of a group of examinees between one test administration and another. The obtained correlation coefficient is an estimate of the *test-retest reliability.* A high, positive test-retest reliability coefficient means that the rank order of examinees' scores on one administration of the test closely approximates the rank order of their scores on another administration. This does not mean that actual score values stay the same for a given person from one test administration to another. But it does mean, for example, that a person who scored in the top 25 percent of the group on the first test administration would also tend to score in the upper quarter of the group on the second administration.

Another way of estimating test reliability is by having examinees take two *parallel forms* of a test, then correlating the scores from the two forms. The two forms might consist of different items that are designed to measure the same things and are equally difficult. A high, positive parallel form reliability coefficient means that the rank order of examinees' scores on one form closely approximates their rank order on an alternate form of the test.

A third way to estimate reliability is to assess the *internal consistency* of a single test. One way of doing this is to have a group of examinees take the test and

TABLE 20.1 **Reliability Coefficients for WAIS Subtests and Scales**

Test	Age 18–19 (200 subjects)	Age 25–34 (300 subjects)	Age 45–54 (300 subjects)
Information	0.91	0.91	.092
Comprehension	0.79	0.77	0.79
Arithmetic	0.79	0.81	0.86
Similarities	0.87	0.85	0.85
Digit span	0.71	0.66	0.66
Vocabulary	0.94	0.95	0.96
Verbal IQ	0.96	0.96	0.96
Digit symbol	0.92	—	—
Picture completion	0.82	0.85	0.83
Block design	0.86	0.83	0.82
Picture arrangement	0.66	0.60	0.74
Object assembly	0.65	0.68	0.71
Performance IQ	0.93	0.93	0.94
Full-Scale IQ	0.97	0.97	0.97

Source: Adapted from Wechsler (1958).

then correlate their performance on even-numbered items with performance on odd-numbered items. This is known as the *split-half* method of determining internal consistency.

Most of the major tests of intelligence have been subjected to reliability assessments, and some tests have proved to be more reliable than others. For example, test-retest reliability coefficients of the Stanford-Binet and WAIS exceed .90, and generally are higher than reliability coefficients for other tests of intelligence. (Recall from Chapter 3 that a *perfect* correlation is 1.00.) Reliability coefficients for the WAIS are given in Table 20.1.

Validity

A test's validity is the degree to which it measures what it was designed to measure. Like reliability, the validity of a test can be estimated in different ways, with each method actually reflecting a different kind of validity. There are three major kinds of test validity: content validity, criterion validity, and construct validity.

A test has *content validity* if its items are related logically to the ability, trait, or other information the test was designed to measure. An intelligence test that had no items to assess mathematical reasoning, short-term memory, or verbal comprehension probably would be judged low in content validity. This is because most psychologists regard these three items as essential to the concept of intelligence.

The clearest illustrations of content validity are those involving achievement tests. *Achievement tests* attempt to measure knowledge or performance in a particular content area, such as history, mathematics, chemistry, or music. A "history test" that had no items pertaining to historical events would obviously have low content validity.

Perhaps the most straightforward of all measures of validity is criterion validity. A test has *criterion validity* if its results correlate highly with other measures of the ability or trait the test is designed to assess. One kind of criterion validity is called *concurrent validity,* which is estimated by correlating examinees' scores on one test with their scores on another test designed to measure the same thing and known to be reliable and valid. For example, people's performance on a *new* test of intelligence is sometimes correlated with their scores on the Stanford-Binet or Wechsler scales in order to determine the concurrent validity of the new test.

Another kind of criterion validity is called *predictive validity.* A test has predictive validity if it correlates highly or at least moderately with a measure of performance that the test is designed to predict. To determine the predictive validity of an intelligence test, for instance, one might correlate IQ scores of a group of individuals with their grades in school or ratings by teachers. Predictive validity coefficients for the Stanford-Binet range from about .40 to .75 (Aiken, 1979). Although the values of these correlation are far from perfect, they are high enough to make predictions, within certain ranges of error, that are useful to school administrators, teachers, and psychologists.

Construct validity is a more theoretical measure of validity than the other two. In the context of testing, a *construct* is an ability or trait that psychologists attempt to measure. Examples of constructs include such things as intelligence, spatial ability, verbal ability, anxiety, and creativity. An intelligence test with high construct validity will predict a *number* of different behaviors that we can agree reflect intelligence. Determining the construct validity of a test is often a lengthy task; it involves relating test performance to a variety of other behaviors that are assumed to reflect what the test attempts to measure.

As an example, consider what might be involved in determining the construct validity of a test of spatial reasoning ability. We might hypothesize that persons with high spatial test performance should also do well in real-world spatial tasks, such as disassembling and rebuilding an automobile engine, finding their way back home after taking a circuitous trail through an unfamiliar setting, or navigating by use of maps and charts. Research studies could be undertaken that would attempt to test our hypothesis by comparing individuals with high and low spatial test performances in these various "real world" situations.

In order for any test to be valid, it must be reliable, but a test's reliability is no guarantee of its validity. For example, a test may produce consistent results, but these results may be unrelated to what the test is supposed to assess.

The "True" IQ

Generally speaking, intelligence tests are more reliable and valid than other psychological tests, such as those that assess various aspects of personality. However, reliability coefficients of even the best intelligence tests are less than 1.00, and predictive validity coefficients are far from perfect. In other words, we expect some degree of variation in the scores a person would receive if tested on different occasions, or with alternate forms of the test. In addition, an individual's test score will be accurate in predicting performance in other situations only within a margin of error. For example, there are people who score well above average on an intelligence test but are high school dropouts. Therefore we must be very cautious when interpreting test scores.

A person's "true" IQ score will be equal to the obtained score plus or minus a given amount. This given amount is called the *standard error of measure-*

ment, which estimates the amount of error involved in assigning an IQ score to an individual. In intelligence testing, standard errors of measurement can vary depending on the test used, the age of the individual tested, and the obtained IQ. For example, suppose that an eighteen-year-old college student takes the Stanford-Binet and receives an IQ of 125. The standard error of measurement for people in the fourteen-to-eighteen-year-old age bracket scoring between 120 and 129 is 4 points. What this means is that the person's true score should be 125 ± 4, with a 68 percent level of confidence. Stated another way, if the individual were to take the test 100 times, and if we calculated a confidence interval each time (obtained IQ ± one standard error), 68 of the 100 intervals would contain the person's true score. Thus, the probability that the interval 121 to 129 contained the true score would be .68. If a higher level of confidence is desired, then the value of the standard error will increase, making the confidence interval much larger. Greater confidence in estimating a person's true IQ is achieved only at the expense of increasing the range of possible outcomes.

As test reliability increases, the standard error of measurement decreases. The more reliable the test, the more precise we can be with respect to locating the individual's true score.

The Meaning of an IQ

What does an IQ score mean? It is simply an indicator of a person's standing relative to others who have taken the same test. A person with an extremely low IQ is not likely to do well in school, but a person with a very high IQ probably can adapt quite well to an academic situation. You should note, however, that these are *probabilistic,* not deterministic, statements. The probability of having an automobile accident is higher for those who are sixteen to twenty-five years of age than it is for older adults, but this does not mean that individuals in this age range are destined to have an accident. Some people with low IQs have done well in school; there are even cases on record of individuals who were classified as "dull" or "borderline retarded" when they were children but who eventually earned advanced degrees. The IQ is not a magical, fixed entity. For any given individual it is subject to fluctuation, and it may or may not be a good predictor of academic success.

The Development of Intelligence

As soon as it became feasible to measure intelligence, one of the first questions posed by many psychologists concerned the relationship of intelligence to development. Would measured intelligence remain fairly constant over the years, allowing fairly accurate predictions of IQ from one age to another? Or would indices of intelligence change with development? Aside from theoretical considerations, these questions have important applied implications. If intelligence, and therefore learning ability, remains constant over the life span, then it might be possible to predict how well a child will do in school long before school age. Such predictions would allow successful placement of children in various programs *prior* to school entrance. If we find that measured intelligence begins to decline in old age, it may be possible to design procedures that prevent or lessen the magnitude of this decline.

Infant Intelligence

As soon as the mental testing movement had begun in earnest, many psychologists, pediatricians, and neurologists explored the possibility of measuring intelligence in infants. One of the first attempts was made by Kuhlmann, who revised the Stanford-Binet so that it could be used with infants as young as three months of age (Kuhlmann, 1922). Subsequent infant tests were developed by the influential pediatrician Arnold Gesell (1925) and by psychologists Nancy Bayley (1933) and Psyche Cattell (1940). The tests most widely used today are revisions of the Bayley and Cattell scales. The Bayley is designed to test children as young as one month, and the Cattell scale's age range begins at two months.

Infant intelligence tests are heavily loaded with items that assess sensorimotor aspects of development, especially during the first year of life. Items for infants under a year of age tend to be concerned mainly with such things as attention to visual and auditory stimuli, visual tracking, grasping and manipulating objects, smiling, imitating, searching for a hidden toy, holding the head up, turning over, sitting up, creeping, standing, and other motor behaviors. The content of these tests for children in their second and subsequent years of life tends to be increasingly verbal, reflecting increasing linguistic accomplishments. For example, there are items that assess the child's ability to follow verbal directions, to remember a series of items, and to correctly name objects.

Tests of infant intelligence such as the Bayley and Cattell scales have proved to be moderately to highly reliable. For example, the 1969 revision of the Bayley scales has split-half (internal consistency) reliability coefficients ranging from .81 to .93. Test-retest reliability coefficients are generally not as high, but are highest when obtained over short test-retest intervals. The validity of current tests of infant intelligence varies depending on the kind of validity assessment that is made. In general, *content* validity is high but *predictive* validity, with certain exceptions, is low. In other words, the content of infant tests includes a representative sampling of infant behaviors that, logically, seem related to infant intelligence. However, with the exception of extremely low infant test scores, performance on infant intelligence scales does not accurately predict overall intellectual performance at a later age. For example, Cattell (1940) found that scores on her test for infants three months of age correlated only .10 with the Stanford-Binet IQ scores of these same children at three years. This correlation is so close to zero that for all practical purposes it can be assumed that the Cattell had no predictive value with

Items on infant intelligence tests typically assess the development of motor skills, such as the age at which an infant begins to walk.

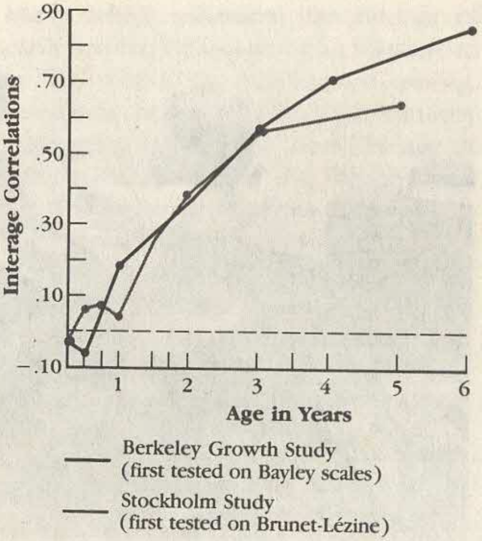


FIGURE 20.2 The ability of intelligence test scores (Bayley and Brunet-Lézine) obtained during infancy and the preschool years to predict Binet IQ scores obtained by the same children at eight years of age. The older the children were when tested on the Bayley or Brunet-Lézine, the higher was the correlation between these scores and the Binet scores.

respect to Binet IQs. Generally, it has been found that the ability of infant test scores to predict later IQ increases with age. Figure 20.2 shows this relationship for two infant intelligence tests—the Bayley scales (1933) and the Brunet-Lézine test, a French translation and modification of the Gesell infant scales. Points on the graph represent correlations (predictive validity coefficients) between performance on these tests taken at various ages and on the Stanford-Binet when the children were eight years of age. As you can see, the correlations are not even moderately high until about four years of age, when they reach .60 to .70. Tests taken before this age have very poor predictive value with respect to the Binet scores at age eight. You should note that after age nine correlations between IQ test-retest scores, even after long intervals, often exceed .90.

What accounts for the lack of predictive validity associated with infant tests of intelligence? Some psychologists, Bayley (1955) included, have argued that intelligence is not a unitary and integrated entity that is present in some degree at all ages. Infant scales may therefore be measuring components of intelligence that are quite different from those that are tapped by tests designed for older children and adults. The fact that infant tests focus heavily on sensorimotor skills, while tests for older children assess mainly verbal skills, seems to support this view.

It is possible, of course, that there *are* skills and behaviors in infancy that predict later intellectual performance, but that testing instruments devised thus far are relatively insensitive to them. By assessing specific infant behaviors under a variety of conditions, we may yet find significant relationships with aspects of intelligence at a later age. Roe, McClure, and Roe (1982) found that the *differential vocal responsiveness* (DVR) of three-month-old infants was correlated significantly with their performance on various intelligence and achievement tests at twelve years of age. The DVR is a measure of an infant's vocal activity in the presence of a responsive stranger, subtracted from vocal activity in the presence of a responsive mother. Infants with high DVR scores vocalize much more with their mothers than with strangers, while those with low DVR scores divide their vocal activity more evenly between mother and stranger.

The correlations Roe et al. found indicate that infants with higher DVR scores tended to score higher on certain tests taken nearly twelve years later than did those with lower DVR scores. What is most impressive is the *size* of the correlations with DVR scores: .79 for the WISC-R Verbal Subscale, .68 for the *Peabody Picture Vocabulary Test,* .63 for the *Wide Range Achievement Test (WRAT),* and .81 for the Arithmetic Subtest of the WRAT. These findings suggest moderate to strong relationships between infant differential vocalizations and later verbal intelligence and achievement.

Intelligence After Infancy

Research during the first half of the twentieth century indicated two major trends in the development of intelligence as measured by IQ tests. First, on the average, performance on the tests (the number of items passed) improved with age during childhood, began to level off during adolescence, reached an apex during early adulthood, and thereafter declined (Figure 20.3). Second, on the assumption that IQ is a measure of innate learning capacity, and in view of the high test-retest reliability of IQ tests, it was concluded that IQ remains relatively stable after age seven or eight. These two trends continued to be publicized well into the 1960s, and many people today believe that intellectual decline during adulthood is inevitable and that one's IQ remains "genetically fixed" over the years. However, more recent research suggests that these trends and interpretations are in error.

The conclusion that intellectual growth peaks during early adulthood and then begins to decline was based on *cross-sectional* studies, in which people of different ages were tested at the same time, and then performance of the different age groups was compared. However, differences among age groups may not reflect development; for example, differences between young and old subjects may be due to cultural, educational, or health factors that were different for the two groups when they were growing up. A group of sixty-five-year-old subjects tested in 1940 might well have had a dramatically different cultural and technological environment during their first twenty years or so than a group of twenty-five-year-old subjects tested at the same time. If we find that the average intellectual performance of the sixty-five-year-olds was significantly lower than that of the younger group, are we justified in inferring that intellectual performance declines significantly between the ages of twenty-five and sixty-five? The answer is no, because it is quite possible that the sixty-five-year-olds' performance did not decline from what it would have been had that group been tested forty years earlier.

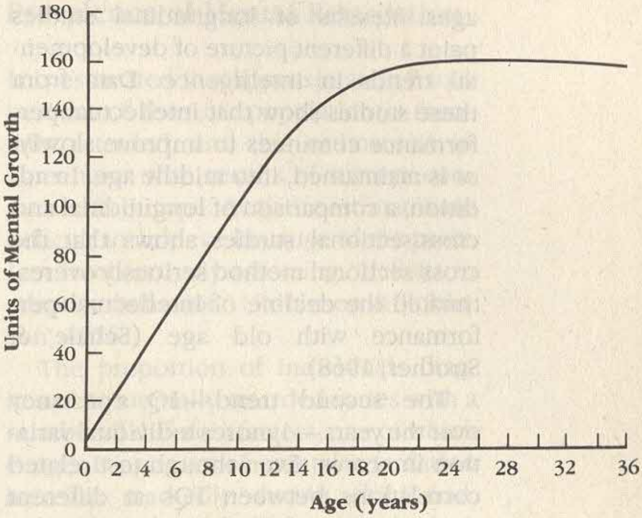


FIGURE 20.3 Theoretical curve of intellectual growth, based on the Berkeley Growth Study.

A more sensitive but also more costly research design for assessing age-related changes is the *longitudinal* method—testing the same individuals at different ages. Results of longitudinal studies paint a different picture of developmental trends in intelligence. Data from these studies show that intellectual performance continues to improve slowly, or is maintained, into middle age. In addition, a comparison of longitudinal and cross-sectional studies shows that the cross-sectional method seriously overestimated the decline of intellectual performance with old age (Schaie & Strother, 1968).

The second trend—IQ constancy over the years—ignores individual variation in scores. Even though test-related correlations between IQs at different ages may exceed .90, this only means that a person's standing *compared to others* stays about the same from one test administration to the next. The actual value of the IQ score may change substantially, however, for any given person. When we examine *individual* curves we see that some people's intelligence test scores decline over the years, some improve their performance, and others fluctuate up and down. We see even more variation in individual IQs in children and adolescents than we do in adults. McCall, Applebaum, and Hogarty (1973) summarize their observations of IQ variation within individual subjects in a longitudinal study conducted by the Fels Institute:

> Normal home-reared middle-class children change in IQ performance during childhood, some a substantial amount. In the present sample, the average individual's range of IQ between 2½ and 17 years of age was 28.5 IQ points, one of every three children displayed a progressive change of more than 30 points, and one in seven shifted more than 40 points. Rare individuals may alter their performance as much as 74 points (p. 70).

Some of the observed individual variation in intellectual performance appears to be systematic; that is, it can be predicted from a knowledge of certain variables. For example, there is evidence to show that boys' IQs tend to increase more than girls' as they grow older (Sontag, Baker, & Nelson, 1958). There are also longitudinal data showing that the IQs of children living in relatively impoverished rural sections of the United States tend to decline with age (Kennedy, Van de Riet, & White, 1963; Kennedy, 1969). This does not mean that *all* boys show greater gains in IQ than girls do, or that *all* children in rural areas show declines in IQ. The results of these studies are *averages.*

As more research is completed, we may begin to identify certain environmental circumstances in the family, school, and society that can affect improvement or decline in intellectual performance. It seems quite likely, though, that environmental variables such as nutrition, health care, quantity and quality of education, and opportunity for self-improvement will not account for *all* of the age-related variation we see in measured intelligence within individuals. Because intelligence is in part *heritable* (see Chapter 5), the influence of genotype interacting with environmental factors cannot be ignored. For example, some people, because of their genetic makeup, will be better able to withstand an impoverished environment and will show less decline in intellectual performance than others in that environment.

Intellectual Retardation

A widely accepted definition of *mental retardation* is that of the American Association on Mental Deficiency (AAMD): "**Mental retardation** refers to significantly subaverage general intellectual functioning existing concurrently with deficits in adaptive behavior and manifested during the developmental period" (Grossman, 1973, p. 11). A subnormal IQ score alone is not enough to warrant the label *mentally retarded*. There must also be an impairment in the individual's ability to adjust to the day-to-day demands of the environment, such as those associated with school, work, family, and friends. In addition, mental retardation is considered a *developmental* disorder. Those who have intellectual deficits due to brain damage or disease that did not emerge before the age of eighteen years are not considered mentally retarded.

"Significantly subaverage" intellectual performance is considered by the AAMD to be intelligence test performance more than two standard deviations below the mean. IQ scores below 68 on the Stanford-Binet (with an IQ standard deviation of 16) and below 70 on the Wechsler scales (with an IQ standard deviation of 15) would be considered significantly subaverage. The current AAMD classification of mental retardation according to IQ is shown in Table 20.2.

Prevalence of Mental Retardation

It is estimated that approximately 2 to 3 percent of the U.S. population is mentally retarded, and this estimate is in agreement with results of surveys conducted in Europe. Accurate estimates are difficult to achieve because of the problem in objectively assessing "deficits in adaptive behavior" (Robinson & Robinson, 1976).

The proportion of individuals diagnosed as mentally retarded varies with a number of different factors, one of which is age. Diagnoses of mental retardation increase markedly during childhood, peak during adolescence, and drop sharply during adulthood. This variation may be understood in terms of the increased "noticeability" of the retarded during the school years. Before school age many mildly retarded children may manage quite well at home, and their development may not be dramatically different from that of their siblings. However, once the child is in school, the intellectual deficits become more obvious. The mildly retarded child is viewed in relation to many other children in a learning environment, and typically does not fare well. The demands of successive levels in school continue to outpace the intellectual growth of the retarded child

TABLE 20.2 Classification of Subaverage Measured Intelligence

Stanford-Binet IQ Score (standard deviation = 16)	Wechsler IQ Score (standard deviation = 15)	Classification	Percentage of Population
68–83	70–84	Borderline	13.6
52–67	55–69	Mildly retarded	2.1
36–51	40–54	Moderately retarded	0.1
20–35	25–39	Severely retarded	0.003
<20	<25	Profoundly retarded	0.0000005

at an ever increasing rate. Therefore it is not surprising that the proportion of children diagnosed as retarded increases with age through adolescence. However, there are occupations or situations that are not intellectually demanding, and in which some of the mildly retarded may find a niche upon achieving adulthood. Others may exist marginally, but "more or less making it," as Robinson and Robinson (1976) put it.

Causes of Mental Retardation

It is estimated that well under 20 percent of the retarded suffer from *known* organic brain disorders having genetic or environmental origins. Of these, a number of factors are known or suspected to be causally related to mental retardation. Genetic disorders include *phenylketonuria,* discussed in Chapter 5. The disorder called *Down's syndrome,* involving an extra chromosome attached to one of the twenty-three pairs of chromosomes, has genetic and environmental origins. Mental retardation has also been associated with certain diseases contracted prenatally, such as *syphilis* and *rubella* (German measles), and with accidental brain injury sustained before, during, or after birth. Cases of retardation associated with identifiable organic factors are likely to result in severe or profound retardation.

Although this person has Down's syndrome, she is not prevented from participating in and enjoying a track and field event.

The factors responsible for the majority of cases of mental retardation cannot be identified precisely, but are thought to be a result of the interaction of genetic and environmental factors. Most retarded individuals with no obvious organic impairment are only mildly or moderately retarded, and fit within the normal curve of intelligence. This is not the case for the severely and profoundly retarded, however; these groups include slightly more individuals than would be expected in a normal distribution of intelligence. If we assume a polygenic model of inheritance for measured intelligence, then the mild and moderate levels of retardation can be explained as the result of unfavorable combinations of genes interacting with unfavorable environments. On the other hand, severe and profound levels of retardation are more often the result of *single* gene effects, as in PKU, or a consequence of disease and injury.

Treatment and Prevention of Mental Retardation

There was little in the way of humane treatment of the mentally retarded until the nineteenth century. Even then, "treatment" was often synonomous with institutionalized custodial care. However, there was renewed interest in the plight of the retarded during the 1960s, with special emphasis on deinstitutionalization, remediation, and the teaching of self-help skills. In particular, mildly retarded children were removed from institutional settings whenever possible and placed in special classes or integrated into regular classes in public and private schools. Training typically emphasized vocational and, to a lesser extent, necessary academic skills. More recently a greater premium has been placed on developing personal and social skills, since these can often determine acceptance or rejection of the retarded by people in the community.

Research carried out since the 1960s has highlighted specific inadequacies in cognitive functioning that characterize the mildly and moderately retarded. For example, it has been shown that, as a group, the retarded tend not to use effective organizational and rehearsal strategies in memory tasks as often as the nonretarded do (Ellis, 1970; Spitz, 1966). In these respects retarded people function much like nonretarded children of preschool age. They seem to be *capable* of using such strategies to aid their memory, but left to their own devices it is unlikely that they will. More recent research indicates that rehearsal strategies can be induced in retarded subjects and, under some conditions, may be maintained for as long as six months (Brown, Campione, & Murphy, 1974). Such findings suggest that it would be feasible to teach the retarded how to use or improve rehearsal and perhaps other cognitive strategies, and that this kind of educational focus might well improve the learning performance of the mildly and moderately retarded.

Great strides have also been made in treating the severely retarded. Little was expected of these individuals in the past, and they were usually relegated to purely custodial care. They had to be clothed, washed, fed, and looked after, much as a parent would look after an infant. However, procedures based on principles of instrumental and observational learning have proved extremely effective in conditioning self-help skills in these individuals. Using the operant conditioning techniques pioneered by Skinner and his associates, psychologists have "shaped" the behaviors of many severely retarded individuals in a very adaptive manner. Even seemingly difficult habits, such as toilet training, can be established in a very short period of time using operant techniques (Azrin & Foxx, 1971).

For nearly any disorder, physical or psychological, prevention usually receives less emphasis than treatment. In the case of retardation, a major obstacle to successful preventive techniques is of course lack of precise knowledge of the cause of the disorder. One of the few clearly successful preventive measures for retardation resulted from the discovery of the cause of PKU. Screening newborns for PKU is now mandatory in many hospitals in North America. Early identification leads to a treatment program that will reduce or prevent mental retardation. Although specific causes have not been identified in most cases of mental retardation, certain procedures appear to be helpful. Programs that result in better prenatal and postnatal health care, and those that provide early physical, cognitive, and emotional enrichment for infants "at risk" for retardation, currently offer the most promise of being moderately effective in reducing the incidence of mental retardation. However, large-scale preventive programs are expensive and difficult to implement (Robinson & Robinson, 1976). And over the past several years in the United States, federal and state funding for social service programs such as these and for basic research into the causes of mental retardation has declined. Although we have made important gains in understanding and treating mental retardation, "cures" still elude us, and the road to understanding and dealing effectively with this developmental disorder is likely to be long and filled with obstacles.

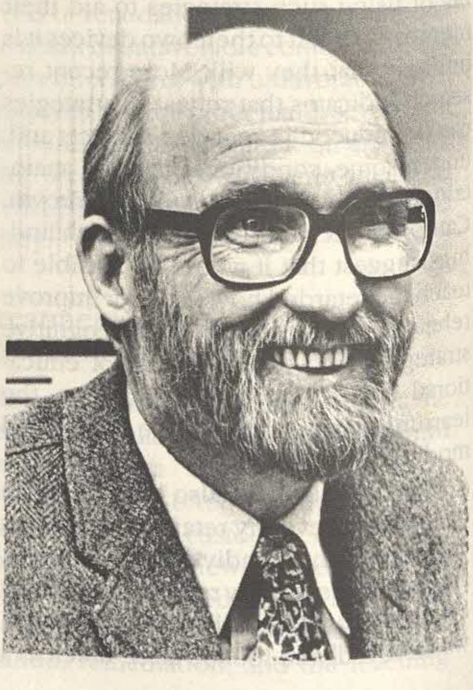
The Intellectually Gifted

In contrast to the situation with mental retardation, there is no clear-cut definition of intellectual giftedness, and there has been little research directed toward delineating and understanding it. Usually a child is identified as intellectually gifted if he or she has an IQ of 130 or higher. But the standards for different schools and communities vary, some using higher or lower scores.

In the past intellectual giftedness was greeted with suspicion, and to a certain extent this is true even today. Children who were advanced intellectually were often considered eccentric and socially maladjusted, and assumed to be physically weak and more likely to become emotionally disturbed. But longitudinal research conducted by Terman, who helped develop the Stanford-Binet intelligence test, indicates that these stereotypes have little basis in fact. Based on a thirty-year follow-up of nearly fifteen hundred children, Terman (1954) observed that children with IQs of 140 or higher tend to be better adjusted socially, and to have better physical fitness than children of average intelligence. Terman based these conclusions on carefully documented records and ratings of health, social behavior, school achievement, and productivity as adults.

One of the major controversies about the intellectually gifted involves educational acceleration. Many educators counsel against advanced placement of the gifted child in school, even though the child is capable of advanced work. They argue that it is detrimental to children to remove them from their same-age peers and place them with older children. Critics of this policy point out, however, that there is little objective evidence to support this concern, as long as the child is eager to move ahead. They reason, as Terman did, that gifted children are not challenged and become frustrated when forced to remain in their

Psychologist Hal Robinson started an early entrance program at the University of Washington in the late 1970s for academically gifted children and adolescents. Students admitted to the program are able to take regular university classes and to pursue a degree, even though they are typically much younger than regular university students. The program also provides counseling and other support services for enrolled students.



age-determined grade, and may develop habits that lead to poor academic performance or dropping out of school altogether. Keeping gifted children in age-determined grades may mean not only individual unhappiness for the children but the loss to society of potentially effective leaders, scientists, and artists.

There has been a recent upsurge of interest in intellectual giftedness, and a number of programs have emerged that are attempting to offer enrichment to this population. However, widespread public support for such programs is lacking. On the surface it appears to many that the gifted do not require special programs and support; compared to the handicapped, the gifted have the wherewithal to make it on their own. However, too little is probably known about intellectual giftedness to determine whether this statement can be justified. Considering the gifteds' enormous potential for contributing to the welfare and betterment of society, further research involving the intellectually gifted would seem warranted.

Intelligence and the Nature-Nurture Controversy

Galton and other early "mental testers" believed that their tests of sensorimotor reactions, which were precursors of IQ tests, measured *innate* capacities. Many of those who followed Galton and developed the first intelligence tests felt the same way about their IQ tests. Several of them, including Terman and Yerkes, were active in the eugenics movement, hoping to improve the lot of humankind by encouraging selective mating. They believed that the "bright," identified by high IQ scores, should be encouraged to mate—but only with others who were bright. The "dull," identified by low IQs, should be persuaded not to have children. The eugenics movement of the early 1900s was based on three assumptions: (1) abilities we label "intelligence" have a very strong genetic component; (2) because intelligence is genetically determined it remains fixed over time for any given individual, unmodifiable by the environment; (3) the aspects of intelligence that are influenced genetically are those aspects that are measured by intelligence tests. Even though methodologically sound evidence in support of these assumptions was lacking, the eugenics movement flourished for a time, a testament to how firmly the belief in hereditary intelligence was entrenched in the United States and other countries.

Not everyone was a "believer," however. For example, in the 1920s the famous American columnist Walter Lippmann published a series of articles attacking intelligence tests as arbitrary and narrow measures of ability; he particularly criticized the idea that an IQ score tells about *innate* intelligence. Lippmann was countered by Terman, but the issue went unresolved. Interestingly, Lippmann's arguments were some of the very same ones that IQ critics in recent years have used. As Block and Dworkin (1976) note, Lippmann argued that

> there is no scientific basis for the claim that IQ tests measure intelligence; that IQ tests consist of arbitrary stunts; that emotional responses to the tests influence scores; that correlations with school success are nonvalidatory because school success itself is not a reliable index of intelligence; and that even if the tests measure ability, they probably measure a rather narrow kind of scholastic ability (pp. 2–3).

Despite the critiques by Lippmann and others, studies of identical and fraternal twins during the 1930s and '40s seemed to bolster the claims of innate intelligence. As we indicated in Chapter 5, these studies revealed higher correlations between the IQ scores of identical twins (same genotypes) than of fraternal twins (different genotypes). The higher correlations for identical twins were interpreted as due to the greater *genetic* similarity of these twins, although it is also possible that the correlations could reflect greater environmental similarity compared to fraternal twins.

During the 1950s and '60s the initial impetus of the testing movement had subsided, and the pendulum began to swing from the nature side of the argument to the nurture side. It was clear that the twin data could be criticized on methodological grounds, and that interpretation of the higher IQ correlations among identical twins solely in terms of genetic factors was unjustified. After all, there were differences in the IQ scores of identical twins, and this had to reflect *some* degree of environmental influence. In addition, examination of individual sets of identical twins reared apart sometimes revealed IQ differences of a rather large magnitude. Since genotypes are the same for a pair of identical twins, what else but the environmental variation could account for the observed differences in IQ among the separately reared twins?

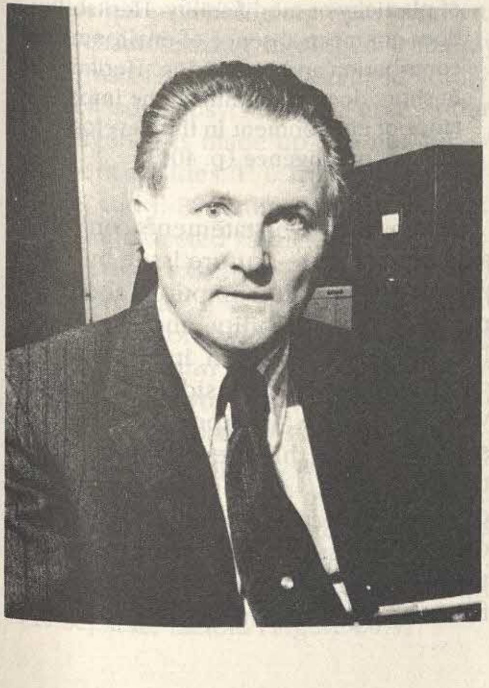
There was also a growing body of research showing that laboratory animals raised with abnormally low amounts of visual, tactual, or motor experience performed poorly in certain conditioning and learning tasks, compared to animals reared in normal laboratory environments. In addition, some studies showed that laboratory animals reared in *highly* stimulating environments tended to perform better than those raised with normal amounts of stimulation (Hunt, 1961; Newton & Levine, 1968; Thompson & Grusec, 1970). This research suggested that individual differences in intellectual performance, at least in certain nonhuman species (mainly rodents), could depend heavily on the quality of the environment during development. Perhaps the same was true for humans.

Couple these research findings with the strong influence of behavioristic learning theories during the 1940s, '50s, and early '60s, which stressed environmentalist explanations of behavior, and it is easy to see how arguments for innate intelligence lost their appeal. And we should not overlook the importance of sociopolitical factors in influencing the shift toward the nurture side of the IQ issue.

During the late 1950s, and throughout the '60s, there was a decided shift toward more liberal values in the United States as well as in many other parts of the world. Great emphasis was placed on the equality of humankind, and on attempts to provide improved environmental opportunities for the oppressed, the poor, women, and others who had been discriminated against, deliberately or otherwise. In the United States it was assumed that an enriched environment for children would result in improved health, learning, social adjustment, and productivity. Large-scale programs such as Project Head Start were designed to increase the intellectual ability of preschool children from economically disadvantaged families by providing massive doses of early environmental stimulation. The sociopolitical climate that spawned the civil rights movement, the women's movement, and unprecedented federal support for the disadvantaged also stimulated a concern for the *modifiability* of abilities. This was hardly a climate conducive to consideration of genetic factors underlying individual differences in intelligence.

Then, in 1969, psychologist Arthur Jensen published a lengthy article in the *Harvard Educational Review* that reignited the IQ nature-nuture controversy, and produced a far-reaching tremor. Going against the tenor of the times, Jensen argued that 80 percent of the *variation* in IQ can be accounted for by genetic factors; only 20 percent is due to environmental variation or the interaction of genotype with the environment. This figure was based on an analysis of the twin study data available at that time. The 80 percent figure was derived from a statistical formula for estimating the *heritability* (h^2) of any trait. Jensen did *not* argue that 80 percent of an individual's IQ is due to heredity. The heritability statistic only estimates what proportion of the *variation* in IQ *among* individuals is due to genetic factors.

Psychologist Arthur Jensen argued in 1969 that individual differences in intelligence are accounted for mainly by hereditary factors. The extension of this hypothesis to explain racial differences in IQ, as well as misinterpretation and distortion of his position in the media, made Jensen an extremely controversial figure during the late 1960s and throughout most of the seventies.



Because Jensen's h^2 estimate was so high, he went on to hypothesize that differences among certain *groups* of individuals are also best understood in terms of genetic differences. In particular, Jensen hypothesized that observed differences in IQ scores between blacks and whites were due primarily to *genetic* differences between the two races. Blacks in the United States score about 15 IQ points below whites on the average. However, most researchers have attributed this difference to the fact that there are proportionately many more blacks than whites living in economically and culturally impoverished environments. Jensen argued that the poorer environments of blacks accounted for little of their subaverage performance on IQ tests; rather, genetic factors were mainly responsible.

Jensen's hypotheses were given immediate publicity by the news media, which often distorted what Jensen actually said. For example, there were accounts that Jensen had claimed blacks were "genetically inferior" to whites, a position Jensen has never taken. Reactions to Jensen's statements also came from psychologists, biologists, educators, and philosophers. Most of these reactions were negative, and some were based more on emotion than on scientific analysis. The nature-nurture controversy was immediately resurrected, and the debate was often more than a little tinged with hostility. It is only recently that the "Jensen controversy" has subsided.

One positive effect of Jensen's stance was a close reexamination of existing IQ data, and of ideas bearing on the nature-nurture issue. Several points can now be made about the heritability of measured intelligence and about Jensen's hypothesis.

1. The heritability statistic can be used meaningfully for understanding variation *within* a group of individuals, but not for variation *between* groups. Jensen used data from white twins; therefore his heritability estimate only applies to the white population that these twins represent. We have very little information about the heritability of intelligence in nonwhite populations.

2. Jensen's estimate of .80 is, in all probability, inflated. Some of the data on which Jensen based his estimate were published by the late British psychologist Sir Cyril Burt. Burt's family study data contained very high correlations for identical twins reared apart, evidence favoring a strong genetic interpretation of measured intelligence. Soon after Burt's death in 1971, however, it was discovered that Burt's family study data contained enough inconsistencies to be considered fraudulent by many scientists familiar with his work (Dorfman, 1978; Wade, 1976). Without these data, and considering more recent findings, Jensen's position is weakened. It now appears that the heritability of IQ may lie anywhere between .30 and .70 (Henderson, 1982).

3. Data collected since Jensen's 1969 paper was published show that black children who have been adopted by white middle-class families do better on IQ tests and in school than would be expected had they been brought up in a family of lower socioeconomic class (Scarr & Weinberg, 1976).

4. Even though Jensen may have overestimated the heritability of IQ, a good deal of evidence from twin studies and adoption studies suggests that IQ is, to *some* degree, heritable. That is, individual differences in IQ reflect, in part, genetic differences. This does not mean that such genetic differences necessarily produce differences in level or kind of learning ability directly. We could be talking about genetic differences that affect different levels or kinds of attentional, motivational, or personality characteristics, all of which could result in different levels of performance on IQ tests.

5. To say that an ability or trait is heritable does *not* mean adopting the *nature* side of the IQ controversy, in opposition to the nurture side. As LaBarba explains,

> It must be emphasized that heritability does not mean nor imply strict determinism. Heritability does not mean absence of plasticity or modifiability. Heritability does not mean absence of environmental contribution and interaction. Heritability, in short, does not diminish the importance of environment in the development of intelligence (p. 401).

Given the overstatements on each side of the nature-nurture issue by a few zealots, the faulty assumptions about the meaning of heritability, and the prevalence of misinformation, it is easy to see why there has been considerable controversy over the interpretation of IQ scores. Add to this the explosive emotional, social, and political consequences of adopting one side or the other of this issue, and it is surprising that we have managed to learn anything at all from the IQ controversy.

Theories of Intelligence

When Binet was experimenting with his intelligence scale in the early 1900s, there was no well-integrated systematic theory of intelligence to guide him. The first theory of intelligence was proposed by Charles Spearman — the **two-factor theory.** Spearman hypothesized that intellectual performance consisted of a general factor (g-factor) and specific factors (s-factors) (Spearman, 1904). **G-factor** was necessary for all kinds of intellectual performance, including performance on tests and in schools. In simplified terms, g-factor was supposed to be a generalized ability that would apply to a number of different situations or tasks. **S-factors** were assumed to be specialized abilities that would allow one to do well on a specific task. Based on intercorrelations of performance on various test items, many psychologists assumed, and some still do assume, that intelligence test performance reflects g-factor, and that g-factor is innate.

Not all psychologists were comfortable characterizing intelligence mainly in terms of a single generalized ability. Rather, some psychologists argued that intelligence is made up of a number of different abilities. T. L. Kelley, L. L. Thurstone, and J. P. Guilford all emphasized the multifaceted structure of intelligence. For example, Thurston (1938) proposed that "g" is composed of several different factors, which he referred to as *primary mental abilities:* verbal comprehension, word fluency, numerical computation, spatial visualization, memory, perceptual speed, and general reasoning. Perhaps the most elaborate multifactor model of intelligence was that proposed by J. P. Guilford (1968). His was a three-dimensional model with 120 separate factors (Figure 20.4).

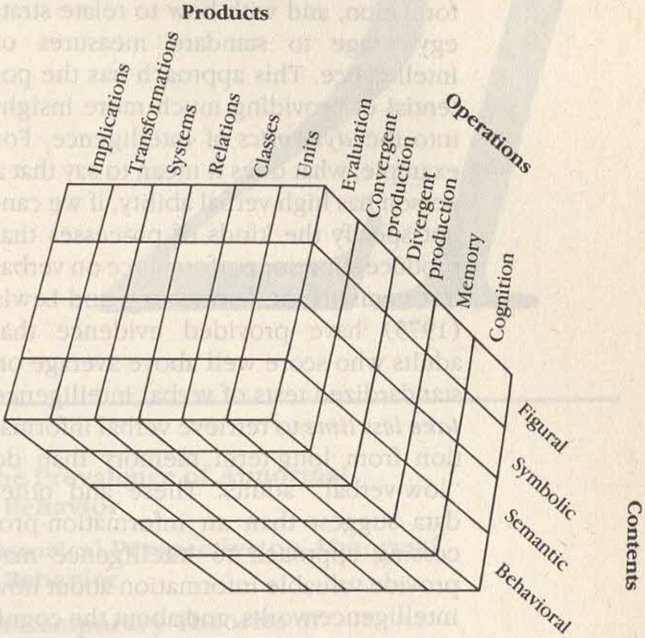


FIGURE 20.4 Guilford's multifactor model of intelligence. Each cell or minicube represents a distinct factor of personality. *Contents, operations,* and *products* make up each of the 120 factors of this model. *Contents* refers to the nature of the problem that must be solved. For example, a test item that requires the subject to supply the correct definition for a word involves semantic content. *Operations* refers to the cognitive activity required to solve the problem. Defining a vocabulary item that one has learned in the past would require the operation of memory. *Products* refers to the results of operating on a specific "content." In the vocabulary item example, the product would be "units" — words.

Many psychologists have expressed dissatisfaction with all factor theories of the structure of intelligence, and have proposed alternative ways of understanding intellectual performance. For example, Earl Hunt and his colleagues have proposed that we consider intelligence from an *information-processing* perspective (Hunt, Frost, & Lunneborg, 1973). They are concerned mainly with how people vary in the use of strategies for encoding, storing, and retrieving information, and with how to relate strategy usage to standard measures of intelligence. This approach has the potential of providing much more insight into the *dynamics* of intelligence. For example, what does it mean to say that a person has high verbal ability, if we cannot specify the kinds of processes that produce superior performance on verbal test items? Hunt, Lunneborg, and Lewis (1975) have provided evidence that adults who score well above average on standardized tests of verbal intelligence *take less time* to retrieve verbal information from long-term memory than do "low-verbal" adults. These and other data suggest than an information-processing approach to intelligence may provide valuable information about how intelligence works, and about the cognitive processes that result in more, or less, intelligent behavior.

Other psychologists have questioned the very notion that IQ tests are adequate measures of what we normally consider intelligent behavior. To some, intelligence is a much broader class of phenomena than what intelligence tests measure. Piaget's theory, which we described in Chapter 14, addresses the structure, functions, and development of intelligence. But intelligence for Piaget is a much broader and more dynamic concept than it is for the "factor" theorists.

Psychologist William Charlesworth (1976) has also argued that we need to define and view intelligence from a broader perspective. Charlesworth suggested that we observe intelligent behavior as it occurs naturally in nonacademic environments, and that we consider intelligence from an evolutionary perspective. He concluded that traditional "testing" approaches to intelligence have reached a dead end:

> It is now time for [traditional intelligence testing] to open itself to other disciplines, disciplines that deal with intelligence in terms of evolution, comparative animal studies, problem solving in various cultures, and just plain everyday behavior. While the historical-evolutionary comparative dimension of intelligence is important for helping us detect what the recurrent and important environmentally posed problems and modes of solving them are, the more immediate problem of making intelligence testing more ecologically valid and hence socially and personally more relevant has to be tackled.
>
> To date, the environment has been almost totally left out of considerations of the origins, nature, and efficacy of human intelligence . . . it is important that we shift our emphasis from intelligence, the disposition, toward intelligent behavior, the process of adaptation. To do this we have to deemphasize intelligence testing momentarily and emphasize the study of intelligent behavior in the natural environment (pp. 165, 166).

If theorizing about individual variation in intelligence is to continue, we agree that the concept of intelligence needs to be broadened. Theories of the structure of intelligence that are based *only* on standardized tests of intelligence are quite restrictive. If the tests had been based upon broad and systematic theories of intellectual structure and function, this would not be as great a problem. However, the tests were pragmatic instruments that sampled a narrow range of behavior designed to predict academic performance. Elaborate theories were constructed later to explain the test performance in terms of *general intelligence,* when in fact the only kind of intelligence they can explain is that defined by the designers of the tests.

21

Abnormal Behavior

The Prevalence of Abnormal Behavior

Historical Perspective on Abnormal Behavior

Contemporary Theories of Abnormal Behavior

Classifying Abnormal Behavior

Neuroses

Psychoses

Other Behavioral Disorders

Why Abnormal Behavior?

Chapter Preview

Abnormal behavior is literally behavior that deviates from the norm. However, there is a great deal of societal and cultural variation in deciding which deviant behaviors are abnormal. In addition, abnormal behavior often involves an element of subjective distress, and can impair a person's functioning and ability to carry out the routines of daily living.

Most people lie between the extremes of severe abnormality and little abnormality. In many cases, abnormal behavior seems to be a matter of *degree* rather than kind. As much as 25 percent of the population of the United States may display some type of behavioral abnormality. And if current trends continue, perhaps as many as one in ten people now living in the United States will require professional treatment for abnormal behavior sometime during their lifetimes.

The belief that demonic possession is responsible for abnormal behavior—demonology—is evident throughout recorded history, and was especially pronounced during the Middle Ages. The Renaissance signaled the reawakening of scientific and humanitarian approaches to understanding and treating abnormal behavior, but demonology was slow to lose its influence.

Contemporary explanations of abnormal behavior include biological, psychoanalytic, learning, cognitive, and humanistic-existential theories. These theories are attempts to deal with immediate and developmental causes of abnormal behavior, the *how* of abnormal behavior.

Two major categories of abnormal behavior are *neuroses* and *psychoses*. Generally speaking, neuroses are less disabling than psychoses, although neurotic symptoms may involve a good deal of anxiety or depression. The neuroses include *affective disorders* (depression), *anxiety disorders* (phobias, generalized anxiety, and panic disorders), *somatoform disorders* (conversion disorders), *dissociative disorders* (psychogenic amnesia, fugue, and multiple personality), and *psychosexual disorders*. Major psychoses include *major affective disorders* (bipolar disorder and major depression) and *schizophrenia,* the most bizarre and disabling of all the psychoses.

Although abnormal behavior is sometimes characterized as *maladaptive,* this may not be entirely accurate. In a biological sense, a maladaptive characteristic reduces the chances for survival and reproduction. However, it seems reasonable to speculate that certain behaviors we call abnormal may have had some survival value for our ancestors and may continue to have potentially adaptive consequences for individuals in particular situations.

The word *abnormal* means deviating from the average; thus **abnormal behavior** is atypical or infrequently observed behavior. But consider for a moment what it would mean if deviation from the average were the sole criterion for defining behavioral abnormality. Gifted musical composers, artists, philosophers, mathematicians, and scientists would be considered abnormal. Clearly the genius that has characterized the likes of Bach, Michelangelo, Leonardo da Vinci, Aristotle, Euclid, Darwin, and Einstein is a rare commodity. But only in a purely statistical sense would most of us consider such talent to be abnormal.

To be sure, abnormal behavior deviates from the average. But to be classified as abnormal, behavior must also be *culturally inappropriate.* In purely operational terms, this means that abnormal behavior can be any behavior that a given society, or influential segment of society, determines to be discomforting, inappropriate, or unacceptable. Given the variation in rules and expectations that is evident among societies and cultures, we should also expect to see a good deal of variation in what is considered abnormal behavior . . . and we do.

A man living in a coastal region of North America who insisted on throwing the remains of a fish dinner into the ocean, rather than in the garbage can, might be considered strange. In fact, if this behavior occurred consistently it might be labeled "ritualistic," and the man might be diagnosed as having a compulsive behavior disorder. Now suppose we ask him to explain the ritualistic behavior. He explains that fish live in great houses under the sea, where they assume a human form. During this time they have feasts and great celebrations, during which gifts are bestowed on one another. Once they assume their fish form they sacrifice themselves. Unless their bones are returned to the sea, the fish will not be able to reassume their human form. Failure to return their bones, he concludes, would offend the fish, and the fish might withhold themselves in retaliation, causing humans to suffer.

This story would probably convince us that its creator has more problems than we originally thought. In fact, some psychologists or psychiatrists would seriously wonder whether the man had lost all contact with reality. But this same behavior would be judged quite differently in a different society. To the Native Americans of the Northwest Coast this behavior, and the explanation for it, would have been considered entirely appropriate (Spencer & Jennings, 1965).

There is thus a good deal of *cultural relativism* involved in deciding whether or not a behavior is abnormal. But most mental health professionals would argue that cultural inappropriateness should not be the only criterion. Sometimes people conform to societal expectations, but still experience a great deal of inner turmoil or depression. *Subjective distress* —feelings of upset, fear, sadness, lack of control, or poor self-image, for instance— may therefore be an additional defining feature of abnormal behavior. But here again it cannot be a sole defining feature.

In addition to the notion of subjective distress, we must consider the concept of *psychological handicap.* When a behavior, or the consequences of a behavior, begin to interfere with an individual's ability to cope with family, work, school, recreation, or other aspects of everyday living, we say that the individual has a psychological handicap. The person with a psychological handicap may be unable to make a normal adjustment in the face of even mild stress.

It may be a serious mistake to regard abnormal behavior as an entity that is qualitatively different from normal behavior. In many cases abnormal behavior seems to be more a matter of *degree* than of kind. Most of us lie between the extremes of severe abnormality and little abnormality. This means that most of us, at one time or another, experience mild to moderate degrees of behavioral abnormality.

To be more specific, most people suffer through episodes of anxiety and depression, sometimes extremely intense episodes. Many people on occasion have fleeting thoughts, or even obsessive thoughts, of suicide or aggression. It is not uncommon nowadays to mistrust our own government leaders and the press, or to suspect that big business conglomerates are plotting to take over the economies and governments of the world. And there seem to be large and growing numbers of individuals who have problems directly related to the use of alcohol or other drugs. All of the foregoing could be defining features of various kinds of abnormal behavior. In other words, we are all a little crazy at one time or another. But it is usually only when such behaviors are perceived by others as being inconsistent with reality, or result in a great deal of subjective distress and psychological handicap, that they are considered abnormal.

The Prevalence of Abnormal Behavior

Estimates of the prevalence of abnormal behavior can vary widely, depending upon how rigid the criteria are for defining or diagnosing abnormality. Obviously, estimates will be lower if only professionally diagnosed cases are counted, and higher if undiagnosed individuals are included—for example, those responding to questionnaires concerned with symptoms of abnormality. However, many mental health professionals argue that even estimates of prevalence based upon "loose" criteria may well be conservative. Many people who have emotional disorders go undetected for various reasons, including the lack of emphasis on preventive mental health care, inadequate mental health care facilities, feelings of shame and apprehension that prevent people from seeking psychotherapy, and a fear of being "found out."

It has been estimated that up to 25 percent of the population of the United States may exhibit some type of abnormal behavior for which outside help is needed. If current trends continue, perhaps as many as one in ten people now living in the United States will require professional treatment for abnormal behavior sometime during their lifetime. Table 21.1 contains recent data estimating the number of individuals in the United States classified under various categories of abnormal behavior.

TABLE 21.1 Prevalence of Selected Categories of Abnormal Behavior in the United States

Disorders	Percentage of Total Population Affected
Anxiety disorders	2–4
Major affective disorders	
Major depression	
Females	18–23
Males	8–11
Bipolar disorder	.4–1.2
Schizophrenic disorders	.2–+1
Antisocial personality disorders	
Females	<1
Males	3

Source: American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed.), 1980.

As you can see, the estimated numbers of individuals classified as abnormal is not small. Moreover, many other people who may not display abnormal behavior themselves are nevertheless affected by it. Immeasurable suffering is experienced by families and friends of those with behavioral disorders; then there are losses in worker productivity and the billions of dollars spent on treatment, all underwritten by the consumer-taxpayer.

Historical Perspective on Abnormal Behavior

Abnormal behavior seems to have been with us at least since early recorded history. The early Greeks described conditions such as depression, mania (overactivity), and phobias. Even before that time it is likely that behavioral abnormalities were recognized and treated. Human skulls dating as far back as one-half million years have been found with holes in them that are believed to have been caused by chipping or cutting with a sharp tool. Anthropologists tell us that this practice, called **trephining,** may have been an attempt to release demons or spirits that were held responsible for causing the abnormal behavior. The fact that trephining is still practiced by some primitive tribes is consistent with the notion that it may have been regarded as a therapeutic procedure in early human societies.

This skull shows evidence of trephining, a procedure in which a hole was cut in an individual's head to release demons supposedly responsible for the individual's disordered behavior.

Trephining suggests at least two things about conceptions of abnormal behavior in the Stone Age: (1) the *head* was recognized as having something to do with bizarre behavioral manifestations; and (2) abnormal behavior was assummed to be due to demonic possession or similarly supernatural causes.

Demonology and Abnormal Behavior

The belief that demons cause abnormal behavior is evident throughout recorded history, especially in biblical writings, and later in the writings of the physicians and influential clergymen of the Middle Ages. There were some notable exceptions, however. The Greek physician Hippocrates insisted that mental disorders had *natural* rather than divine causes, and required treatment like other diseases. Hippocrates also considered the brain to be the central organ responsible for intellectual activity, and believed that mental disorder was a result of brain disorder due to an imbalance in the "humors" (blood, black bile, yellow bile, or phlegm) of the body. As far we know, Hippocrates was the first to espouse a *medical model* of abnormal behavior; he assumed abnormal behavior was a sickness reducible to physical pathology. He also argued for humane treatment of the mentally ill.

Following Hippocrates there were others who supported his notions, especially Aristotle and the Roman physician Galen (ca. A.D. 130–200). But later, after the fall of Rome in 476 and the emergence of religious authoritarianism in Europe during the Middle Ages, demonology again became a popular "theory" of abnormal behavior, and "therapies" for abnormal behavior often involved attempts to rid the afflicted individual of demons. These included the rituals of *exorcism* and, in especially resistant cases, torture and death. Notable exceptions to these ideas and practices during the Middle Ages were found in Arabia, where the scientific and humanitarian aspects of Greek medicine continued to be emphasized.

In Europe, the belief in demonology reached its apex during the latter part of the fifteenth century and lasted for another two hundred years. During this time, individuals who behaved in a deviant or otherwise unacceptable manner were sometimes accused of being witches and heretics in league with the devil, and were treated in the most inhumane ways conceivable. Suspected witches were often tortured physically until they "confessed," or were burned at the stake, sometimes while still alive, sometimes after being beheaded, strangled, or mutilated. Between the middle of the fifteenth century and the end of the eighteenth, thousands of people were put to death in North America for being witches (Deutsch, 1946). Historical records suggest that many of them were suffering from recognizable mental disorders; most of them were probably normal, however.

Not everyone in those times accepted the demonology explanation of abnormal behavior. Johann Weyer (1515–1588) stands out as a courageous proponent of the view that many witches were mentally disturbed, not possessed, and needed humane treatment, not torture. At the time Weyer's writings were greeted with ridicule, and they did not begin to achieve acceptance until long after his death.

The Renaissance signaled the reawakening of scientific and humanitarian approaches to understanding and treating abnormal behavior. However, belief in demonology, particularly witchcraft, was slow to lose its influence in European and American societies, and it would be inaccurate to say that demonology as an explanation of abnormal behavior ever died out completely. The recent revival of the popularity of occult practices such as witchcraft and astrology in the United States since the 1960s indicates that supernatural explanations of abnormal behavior are still readily embraced by some people.

> A cursory look at the history of science suggests that supernatural explanations have flourished in areas in which scientific knowledge was limited. When scientific knowledge expanded, supernatural theories retreated to areas still untouched by science. Our understanding of abnormal behavior is still incomplete, and thus, not surprisingly, supernatural views still find room for acceptance. If past history is any indication, demon possession . . . will in time be seen as an unnecessary assumption and be abandoned. Of course, there may always be some people who prefer to believe something other than that which has been reasonably demonstrated to be so, as did members of the Flat Earth Society in the not too distant past (Martin, 1981, p. 29).

Humanitarian Approaches to the Mentally Ill

The emergence of scientific thinking during the Renaissance paved the way for natural rather than supernatural explanations of abnormal behavior. However, humanitarian treatment of the mentally ill was not common until the nineteenth century. Prior to this time, the procedures carried out in the first mental hospitals, called asylums, were often not much of an improvement over the techniques used for extracting confessions from suspected witches. It is no exaggeration to say that patients were treated like animals and criminals in such hospitals as St. Mary of Bethlehem ("Bedlam") in London, the Hospital at Williamsburg (the first in North America), La Bicêtre in France, and the Lunatics' Tower in Vienna. These places were filthy and overcrowded, and many patients were kept confined in chains, irons, and straitjackets. In addition, common therapies included placing patients in devices that would swing them violently in circles and dunk them in water, applying hot irons to the heads of patients, surgically removing "stones" (believed to cause mental illness) from their heads, and jumping on patients to remove their "mental obstructions."

The year 1792 marked the beginning of a humanitarian reform movement that

The humanitarian Philipe Pinel is shown freeing the inmates of the asylum La Salpêtrière.

dramatically changed the ways of caring for and treating those with mental disorders. It was at this time that Philippe Pinel (1745–1826) was placed in charge of La Bicêtre in Paris. He immediately set about removing the chains, instituting standards of cleanliness, and establishing humane therapeutic measures. Pinel did these things because he believed the inmates were fully human, though suffering from mental illness. Pinel's efforts were carried on by others who founded mental hospitals designed to improve conditions for the mentally ill. Among them were Pinel's successor at La Bicêtre, Esquirol, the notable New England reformer Dorthea Dix, and the English Quaker William Tuke.

Nineteenth-Century Views of Abnormal Behavior

Nineteenth-century scientific thinking regarding the causes of abnormal behavior was characterized by two theoretical perspectives—the organic view and the psychological view.

The *organic view* held that all abnormal behavior was symptomatic of some kind of underlying physical pathology. As we saw earlier, Hippocrates had espoused an organic view of abnormal behavior, but this was suppressed during the Middle Ages, as were other nonsupernatural theories. The organic view received a great impetus during the latter half of the nineteenth century from research concerned with **general paresis.** General paresis is a mental disorder in which the patient experiences **delusions** (irrational beliefs), **dementia** (deterioration in thinking and judgment), and progressive *paralysis.* By the end of the nineteenth century scientists were quite sure that general paresis resulted from syphilis. In 1913 this was shown conclusively, when the brain tissue of paretic patients was found to contain the microorganism that causes syphilis, *Treponema pallidum.* It had already been known for some time that the brains of paretic patients showed evidence of destruction of nervous tissue.

The link between symptoms of general paresis and brain pathology associated with syphilis provoked a good deal of optimism that other forms of abnormal behavior would eventually be traced to organic disorders. In some cases this optimism turned out to be well founded, but in most others no simple relationship between organic involvement and the disorders has been demonstrated.

The *psychological view* of abnormal behavior also emerged during the nineteenth century. According to this view, abnormal behavior results from disturbances in cognitive, emotional, and social processes, although some degree of organic involvement is not ruled out. Disturbances in psychological processes may be accompanied by neurological and biochemical changes, as either cause or effect. At the very least, psychological processes are not possible without central nervous system functioning, and so it does not make much sense to consider psychological causes of abnormal behavior totally independent of biology. However, the focus of the psychological view is on causes of abnormal behavior that have no apparent organic basis.

The psychological view emerged primarily from the experiences of neurologists such as Jean Charcot (1825–1893) and Sigmund Freud (1856–1939). Charcot and others found that hysterical symptoms could be removed as well as induced through hypnosis. **Hysteria** is a broad class of disorders characterized mainly by physical symptoms with no apparent organic cause. Fainting, numbness and paralysis, and even impaired vision and hearing that occur for no detectable physical reason are considered hysterical disorders. The effectiveness of hypnosis in altering hysterical symptoms, and the notable absence of underlying physical pathology, eventually convinced Charcot and many others that psychological factors could produce physical and mental disorders.

Freud found that even without hypnosis it was possible to pinpoint suspected psychological causes of hysterical and other disorders and to treat them successfully without medical therapies. In fact, Freud's theory of personality, psychoanalytic theory, was the first systematic *psychological* view of normal *and* abnormal personality.

Contemporary Theories of Abnormal Behavior

Most contemporary theories of abnormal behavior are elaborated and refined versions of the organic and psychological views of the nineteenth century. In fact, we have already discussed four of these theoretical approaches in connection with personality in Chapter 19: biological, psychoanalytic, learning, and humanistic-existential theories. A fifth approach to abnormal behavior is the cognitive theory. These theories are ways of dealing with immediate and developmental causes of abnormal behavior, the *how* of abnormal behavior (Table 21.2).

The *biological* approach emphasizes physiological mechanisms, genetic fac-

TABLE 21.2 Contemporary Theories of Abnormal Behavior

	Focus of Theoretical Approach				
Approach	Physiological Processes	Unconscious Processes	Overt Behavior	Conscious Processes	Experiential Processes
Biological	X				
Psychoanalytic		X			
Learning			X		
Cognitive				X	
Humanistic-existential					X

A comparison of different theories of personality in terms of their primary focus.

tors, and physically traumatic environmental factors in trying to understand abnormal behavior. Abnormal behavior is seen as directly or indirectly related to disturbances in nervous system or endocrine system functioning. Such disturbances may be brought about by genetic changes interacting with the environment, or by the direct action of environmental factors, such as disease, malnutrition, toxic levels of drugs, physical injury, lack of oxygen at birth, and other stressors. The biological approach comes closest to the organic view of the nineteenth century, although it is now much more sophisticated.

The *psychoanalytic* approach emphasizes psychological factors and biological motivation, especially sexual motivation, as responsible for abnormal behavior. In particular, classical (Freudian) psychoanalytic theory focuses upon unconscious sexual impulses and tensions as major forces in producing abnormal behavior. An overactive *superego,* an inadequate *ego,* or excessively strong or unsatisfied drives can lead to conflict, anxiety, and deterioration of personality. Perhaps the most important contributions of Freudian psychoanalytic theory to an understanding of abnormal behavior involve the notions of *unconscious motivation* and *early experience.* Freud was the first personality theorist to formally implicate motivations and conflicts that lie beyond our awareness in abnormal behavior. He also emphasized the importance of experiences in early childhood in structuring later personality development. For Freud, abnormal behavior was ultimately traceable to the first five or six years of an individual's life. It was during this time that a child could become *fixated* in a particular biological stage (see Chapter 19), depending upon the particular experiences the child underwent with his or her parents. Such fixations could lead to permanent scars on the personality, according to Freud.

Many neo-Freudian psychoanalytic theorists have downplayed the primacy of *sexual* conflicts and the notion that abnormalities result from fixations formed before the age of seven. They have also placed greater emphasis on social and cultural determinants of abnormal behavior than did Freud. Nevertheless, most psychoanalytic thinkers agree on the importance of *unconscious* motivation in influencing abnormal behavior.

The *learning* approach views abnormal behavior as a result of classical conditioning, instrumental learning, observational learning, or combinations of these. The emphasis is on *overt* behavior, rather than on conscious or unconscious components of personality, and the influence of the external environment is stressed at the expense of physiological or genetic factors. To understand abnormal behavior, according to this approach, is to discover the stimuli that elicit or reinforce such behavior.

The *cognitive* approach to abnormal behavior focuses upon thinking processes. Cognitive theorists argue that in certain behavioral disorders individuals reason according to false premises. It is possible that such reasoning may influence and maintain certain kinds of abnormal behavior. For example, a person may believe she has absolutely no control over the environment, a false premise that, if maintained, may lead to feelings of helplessness, depression, or even suicide.

The *humanistic-existential* approach to abnormal behavior represents a variety of philosophical and psychological views, most of which share one or more of the following assumptions concerning human nature: These assumptions include: (1) the notion that the *self,* and subjective experience in general, is the proper focus for understanding normal or abnormal personality; (2) the notion that every individual has a *unique self* and that, therefore, the only way we can begin to understand a person's behavior is by viewing things from that person's unique perspective; (3) the belief that there is an innate tendency to *self-actualize,* to progressively develop one's potentials or fulfill one's needs; and (4) the belief that people have free choice, and that the choices we make influence our personalities. Proponents of this approach regard abnormal behavior as arising from a failure to come to grips with one's own experiences. In other words, lack of self-awareness and shutting oneself off to the inner world of subjective experience can lead to emotional disorders. Other contributors to abnormal behavior, in this view, are conditions that impede self-actualization, such as slavish conformity to the perceived demands and expectations of others, and failure to deal with the existential anxiety that accompanies the realization that responsibility must be accepted for one's own actions.

The different theoretical approaches to abnormal behavior that we have summarized are not necessarily mutually exclusive, even though they have evolved out of different traditions, embody different assumptions about human nature, and prescribe different therapeutic measures. In many cases the different theories seem to be focusing upon different levels of analysis—for example, physiological versus cognitive. It is also true that most psychologists and psychiatrists do not subscribe to one theory exclusively. It is recognized that no *single* theory of abnormal behavior can offer an adequate explanation for all forms of abnormal behavior at all levels.

Classifying Abnormal Behavior

Modern classifications of abnormal behavior are much elaborated versions of the first systematic system of classification formulated by Emil Kraepelin (1855–1926). Kraepelin based his system on a medical model involving detailed description of the onset and developmental course of symptoms and diagnosis of underlying pathology. His two major classifications of mental illness were *manic-depressive psychosis* and *dementia praecox (schizophrenia)*. Manic-depressive psychosis involves a severe disturbance in mood states: extreme excitement, activity, and elation (*mania*), and extreme depression (*melancholia*). Sometimes these mood states alternate in the same individual. Dementia praecox involved a variety of symptoms marked by mental confusion and incompetence. Approximately two-thirds of the patients in mental hospitals during the nineteenth century were put in one or the other of these two major classifications. A third, less frequently used diagnostic category was that of *paranoia*, a disorder characterized mainly by delusions of persecution and grandeur.

The system of classification that is most widely used today in North America is the third revision (1980) of the *Diagnostic and Statistical Manual of Mental Disorders*, known as DSM-III. This manual, first published in 1952 by the American Psychiatric Association, serves as a guide to diagnosticians and researchers concerned with abnormal behavior. DSM-III contains several hundred different categories and subcategories, only a few of which are reviewed in this chapter. Table 21.3 gives a partial breakdown of the major DSM-III categories.

TABLE 21.3 DSM-III Categories of Abnormal Behavior

Disorder	Example
Disorders usually first evident in infancy, childhood or adolescence	Mental retardation
Organic mental disorders	Senility
Substance use disorders	Alcohol abuse
Schizophrenic disorders	Catatonic schizophrenia
Paranoid disorders	Paranoia
Psychotic disorders not elsewhere classified	Brief reactive psychosis
Affective disorders	Major depression
Anxiety disorders	Panic disorder
Somatoform disorders	Hypochondriasis
Dissociative disorders	Multiple personality
Psychosexual disorders	Transsexualism
Factitious disorders (disorders that are not genuine)	Factitious disorder with psychological symptoms (voluntary production of severe psychological symptoms)
Disorders of impulse control not elsewhere classified	Pathological gambling
Adjustment disorder (maladaptive reaction to an identifiable stressor)	Adjustment disorder with depressed mood (to the death of a pet)
Psychological factors affecting physical condition (psychosomatic disorders)	Migraine headache
Personality disorders	Antisocial (psychopathic) personality disorder

In clinical practice, diagnostic classification of individuals is usually based upon a careful consideration of a person's *case history, interviews, tests* of personality and intelligence, *direct observations of behavior*, or combinations of these. It would be comforting to think that, after all of this, diagnoses are always accurate. However, although it is too soon to tell how clinicians will fare in using the categories of DSM-III, diagnoses using earlier versions of DSM have not always been highly reliable. In interclinician reliability studies, it is unusual to see correlations above .80 for the major diagnostic categories. Reliability estimates are generally much lower than this for the various *subcategories* of mental disorders. In addition, it has been shown experimentally that normal persons acting normally are more likely to be diagnosed as abnormal if prestigious clinicians *suggest* such an assessment to the diagnostician (Temerlin, 1970).

There are also difficulties with the diagnostic categories in terms of understanding causes and suggesting effective treatments. In most cases the cause, or *etiology*, of the various kinds of abnormal behavior is unknown. For the most part the diagnostic categories are primarily *descriptive* of clusters of symptoms; they do not necessarily suggest a specific cause. It is quite possible that two people, manifesting the same set of behavioral symptoms, may be doing so for quite different reasons. Yet according to current diagnostic practices they would be given the same classification and perhaps the same treatment. This could be akin to diagnosing two people suffering from stomach cramps, nausea, and vomiting as victims of a viral infection. Antacids, rest, and liquids, the standard remedy, could result in serious illness and death if one of the persons in fact has a ruptured appendix.

In spite of the limitations of the classification system, probably most mental health professionals would agree that some kind of system is better than none at all. Some kinds of disorders are known to have definite organic causes, and for others there is evidence implicating genetic involvement. In such cases classification provides more than descriptive information. In many other cases, even though etiology is suspected rather than established, diagnostic classification can at least tell us what symptoms to expect in the future, and that certain therapies can be definitely ruled out. Finally, from a research point of view, some kind of classification is essential, at least as a first step toward describing and understanding abnormal behavior.

The remainder of this chapter is devoted mainly to describing some of the more common or widely publicized types of abnormal behavior, and discussing possible or probable causation. We have divided the disorders into three major classifications — *neuroses, psychoses,* and *other*. Generally speaking, neuroses are less disabling than psychoses, although neurotic symptoms may involve a good deal of anxiety or depression. Psychoses generally involve considerable loss of contact with reality, and usually require that the patient be hospitalized or placed under close supervision, at least temporarily. The "other" classification of abnormal behavior involves a variety of disturbances not traditionally categorized as either neuroses or psychoses.

Neuroses

Neurotic disorders are often characterized as inadequate attempts to deal with conflict and fear brought about by stressors in the environment, external or internal. Psychoanalytic theorists might describe neurotic behavior as an overreliance upon the *ego defense mechanisms.* The defensive behavior becomes neurotic when it fails to reduce the anxiety and actually creates *additional* conflict, thereby interfering with happiness and normal adjustment. The neurotic person invests a great deal of energy in reducing anxiety or trying to block it out altogether.

In contrast to the psychoanalysts, learning theorists often see neurotic behavior as *learned avoidance responses.* In their view, neurotics begin as children to acquire behavioral strategies that avoid or prevent punishing (aversive) stimuli. If the intensity of the aversive stimulus is great enough, even very bizarre behaviors may be adopted, as long as they are effective initially in avoiding the stimulus. Thus a child may learn to stay in his room most of the evening in order to avoid continual parental conflict and harrassment. This *withdrawal* behavior may become neurotic if it keeps the child from engaging in meaningful interactions with family members and friends, or if it becomes the child's standard way of dealing with all kinds of frustration. Both the learning and psychoanalytic theories have a great deal to say about the development and maintenance of neurotic behavior, and because of this we shall examine these two approaches in more detail than others in this section.

Regardless of how one characterizes it theoretically, neurotic behavior represents an ineffective defense against stress. There is in fact a paradox here. As strategies of avoiding conflict begin to lose their effectiveness, additional stress is created, which stimulates further neurotic behavior. It is as if neurotic individuals are unable to give up their current defenses, and come to rely on them more in spite of increased distress. Neurotic persons apparently lack alternatives for dealing with stress, since they seem unable to adopt a different and possibly more effective strategy. Perhaps the old strategy is stronger simply because it *was* effective in the past and therefore was reinforced. Alternative strategies may have had little opportunity to acquire reinforcing properties. It may also be that the avoidance behavior loses its long-range effectiveness in reducing anxiety, but remains effective on a temporary basis.

Affective Disorders

The term *affect* refers to emotion or mood. **Affective disorders** involve mood states that do not seem appropriate given the circumstances. For example, it is normal to be sad over the death of a pet cat. This sadness may be quite pronounced for several days, but gradually subsides. But deep sadness that lasts for six months or a year following the pet's death would seem unwarranted. Such a case of sadness would probably warrant classification as *neurotic depression,* as would other cases in which the amount and duration of the sadness seems unjustified in view of the observable causes of the sadness.

Cases of depression so severe as to include the possibility of suicide would be diagnosed as psychotic, not neurotic, disorders. We will discuss the etiology of depression when we take up the topic of psychotic affective disorders.

Anxiety Disorders

To be anxious is to be fearful. Anxiety usually consists of symptoms that are intensely *physical* in nature. Symptoms of anxiety can include such things as heart palpitations, tremors, excessive sweating of the palms, rapid breathing, hyperventilation, faintness, dizziness, headaches, chest pains, digestive upsets, and feelings of impending disaster. In addition to the physical symptoms, there may be intense feelings of guilt, and general panic.

Symptoms of anxiety can range from mild to severe. Acute anxiety comes on suddenly; chronic anxiety is experienced over a long period of time. Symptoms can be activated by a specific stimulus or by a whole host of stimuli, or may seem to occur spontaneously.

Phobias Irrational fears of *specific* stimuli, including such things as water, high places, enclosed places, crowds, going out of doors, various animals, weapons, darkness, and thunder and lightning are called **phobias** (Table 21.4). Of course, any of these things could be rational cause for alarm or anxiety under the right set of circumstances. However, the person with a phobia experiences such an intense fear that the phobia-related stimulus usually cannot be

TABLE 21.4 Some Phobic Disorders and Their Eliciting Stimuli

Type	Stimuli
Agoraphobia	Being in public places away from home
Social phobia	Social situations
Simple phobia	
Acrophobia	High places
Algophobia	Pain
Claustrophobia	Enclosed places
Zoophobia	Animals, especially snakes, spiders, and insects

tolerated under any circumstance. For example, a person with a fear of enclosed places may go to great lengths to avoid them, even turning down a job in a building where the use of elevators is unavoidable. There are people so afraid of airplanes or heights that they insist on traveling long distances by train, bus, or car, regardless of the extra time and fatigue associated with such travel.

The two theories that have had the most to say about the development of phobias are the psychoanalytic and learning approaches. According to Freud, a phobia results when a child *displaces* a fear associated with a particular person (usually a parent) to an object, situation, animal, or another person. Freud thought that children in the age range of three to five years would be particularly susceptible to developing phobias. He reasoned that it is at this time that children are faced with an *Oedipal conflict,* which can create a high level of anxiety and fear of the same-sex parent, who is seen as a powerful and threatening rival. Freud reasoned that a boy's fear of his father, for example, could reach such enormous proportions that the child would displace the fear onto an animal or object, which would then function as a symbol for the father at an *unconscious* level of personality. In a sense, the phobia would keep the boy from having to face the nature and true source of his anxiety.

Learning theorists have tried to account for the development and maintenance of phobias in terms of classical conditioning, observational learning, and instrumental learning. From a classical conditioning perspective, a phobia is a response conditioned to a stimulus that has been paired with an aversive event. The aversive event functions as an unconditioned stimulus. The case of the child Albert, described in Chapter 7, illustrates how classical conditioning might work to produce a phobia. You will recall that Albert was conditioned to fear a white rat (the conditioned stimulus) because it had been associated with a loud noise (the aversive unconditioned stimulus). Although Albert's fear was established by means of a contrived experiment, it is quite possible that in everyday circumstances *accidental* pairings of a neutral stimulus with an aversive event could produce a conditioned fear (phobia) related to the previously innocuous stimulus.

Phobias may also be acquired through observation of the responses of models to various stimuli. Hearing someone talk with great apprehension about poisonous snakes may cause a child to internalize a phobia for snakes.

Instrumental learning is thought to help *maintain* phobic responses. People with phobias may engage in behaviors that allow them to *avoid* the phobic stimulus. Successful avoidance of an aversive stimulus is *negative reinforcement* for whatever behavior brought about the avoidance, as we saw in Chapter 8. Thus, a person may develop a fear of enclosed places through classical conditioning or observational learning. But in addition the individual may learn *instrumental* behaviors, such as staying away from elevators, because they are negatively reinforced; they prevent the person from coming into contact with an elevator. Of course, such instrumental behaviors also prevent the phobia from being extinguished. Extinction of a fear requires that the person be exposed to the fear-producing stimulus, but with no occurrence of the original aversive unconditioned stimulus. Instrumental avoidance behaviors would not allow this to happen, and thus the phobia would have little opportunity to extinguish.

There is evidence that unpleasant childhood experiences are indeed associated with phobias, as predicted by both psychoanalytic and learning theories. Phobic persons often recall a traumatic incident from childhood which seems logically related to the fear (Rimm. Janda, Lancaster, Nahl, & Dittmar, 1977). For example, we know a woman who has an intense fear of being in high buildings. We have witnessed the manifestations of this fear on two occasions, once when she was on the observation deck of the Empire State Building in New York, and once while dining at the top of the Space Needle in Seattle. She claims to have experienced great fear as a child of five when her older brother convinced her he was about to drop her over the side of a protective railing several stories up on a building. Interestingly, her fear is specific to high places *in buildings;* she is not afraid of heights while in an airplane, and she has climbed some of the highest mountain peaks in the continental United States without experiencing the phobia. Perhaps this is an instance of a classically conditioned phobia.

Although classical conditioning provides a parsimonious account of the development of phobias, there are indications that it is not a complete account. As we saw in Chapter 7, there is evidence to suggest that classically conditioned aversions are more easily obtained with some stimuli than with others, depending upon the species under consideration. Seligman and Hager (1972) emphasized that not all stimuli are equally effective at eliciting phobias. For example, we rarely see phobias develop for stimuli such as people, chairs, bedsheets, pajamas, eating utensils, or tools. Rather, phobias are most often associated with a restricted range of stimuli that can in fact pose a threat to survival, and surely did so during our evolutionary history. Seligman and Hager and others (for example, Rachman, 1977) believe that we are genetically programmed to associate fear with these stimuli *more than* with others because this predisposition would have had survival value for our ancestors.

Generalized Anxiety and Panic Disorders **Generalized anxiety disorder** is characterized by chronic and long-lasting symptoms of anxiety. **Panic disorder** involves an acute and fairly short-lived onset of symptoms, usually lasting a minute to an hour, which can involve distressing physical symptoms and apprehension. People who frequently experience what are called anxiety attacks would probably be diagnosed as suffering from panic disorder.

Unlike phobias, generalized anxiety and panic disorders are not associated with any specific stimulus. For example, a college student may be walking across campus and suddenly experience a wave of extreme fear, tremors, perspiration, and racing of the heart, which subsides after a few minutes. The same person may also experience these symptoms while driving, while watching television, or while trying to fall asleep. There seems to be nothing in the environment that can be identified as the suspected cause of the anxiety.

Freudian conceptions of the development of generalized anxiety and panic disorders focus upon the id, the hypothetical storehouse of sexual impulses. The idea here is that anxiety develops because id impulses are punished during childhood by the parents. For example, the child may be caught masturbating and punished severely as a consequence. These sanctions are internalized, causing guilt and anxiety whenever the child entertains fantasies and urges. The child eventually represses the *source* of the anxiety, but the repression is not entirely effective in doing away with the anxiety itself.

Learning approaches view the development of anxiety in different ways. One possible explanation involves punishment, as does the psychoanalytic view. Children who have been punished intensely and consistently, for whatever reason, may come to associate fear responses with aspects of the punishment situation—parents, teachers, adults in general, circumstances involving home and school, various words, and so on. The causal mechanism in this case would be one of classical conditioning and generalization of fear elicited by the punishing stimulus.

Another learning view of anxiety—a cognitive view, some would say—involves the notion of *uncertainty* in controlling one's environment. Psychologist Martin Seligman has argued that anxiety represents an initial reaction to the inability to predict outcomes in the environment, especially unavoidable aversive outcomes. According to this view, a child who could *predict* the occasions or cues for being punished would grow up to be *less* anxious than a child who was unable to make such predictions. The inability to predict aversive outcomes could come about if a child were punished indiscriminately and with no advance warning, as happens in some instances of child abuse. Seligman believes this kind of situation can produce chronic anxiety because there are no discernible cues for punishment and, therefore, no cues for *nonpunishment.* Seligman (1975) makes the point nicely in an improbable example involving earthquakes as the unavoidable aversive event:

> Consider a world in which earthquakes are reliably predicted by a ten-minute tone. In such a world, the absence of the tone reliably predicts safety, or the absence of earthquake. As long as the tone isn't on, you can relax and go about your business; when the tone *is* on, you're probably terrified, but at least you have usable safety signals. When traumatic events are predictable, the absence of the traumatic event is also predictable—by the absence of the predictor of the trauma. When traumatic events are unpredictable, however, safety is also unpredictable: no event reliably tells you that the trauma will not occur and that you can relax. . . . in the wake of traumatic events, people and animals will be afraid all the time, except in the presence of a stimulus that reliably predicts safety. In the absence of a safety signal, organisms remain in anxiety or chronic fear. On this view, people and animals are safety-signal seekers: they search out predictors of unavoidable danger because such knowledge also gives them knowledge of safety (pp. 112–13).

We would add that a tendency to seek "safety signals" makes perfect adaptive sense. With the exceptions of laboratory experiments and certain natural disasters, a good many traumatic events *are* avoidable. Characteristic cloud formations and wind patterns can predict life-threatening storms, bird calls can signal the presence of predators, and the crack of a rifle shot in the forest portends danger to human and nonhuman alike. Individuals predisposed toward recognizing the *signaling* features of their environments undoubtedly stood a better chance of avoiding life-threatening situations than those not so predisposed. And it seems quite reasonable that aversive situations which are unavoidable *and* unpredictable would create confusion and anxiety, since these would be the exceptions, not the rule, in an organism's environment.

How do the psychoanalytic and learning theories fare with respect to the development of generalized anxiety and panic disorders? First, there is much evidence to implicate punishing circumstances in the development of generalized anxiety. It appears that anxiety neurotics often come from families in which parents have perfectionistic standards for their children and reject actual accomplishments as being inadequate (Jenkins, 1968, 1969). This would serve as a source of punishment for the child, and perhaps as an unavoidable and unpredictable one.

Second, it is clear from nonhuman experiments that unavoidable and unpredictable punishing stimuli create fear, stomach ulcers, and, in the long run, a tendency to "give up" (Seligman, 1975).

Finally, many individuals do not develop anxiety disorders, even in the face of extremely punishing circumstances. We might therefore suspect that genetic factors interacting with environmental stressors may account for some of the individual differences in manifestations of generalized anxiety and panic disorders. In fact, analysis of data from studies of twins reveals that 41 percent of identical twin pairs (averaging forty years of age) were in agreement, or concordant, for anxiety reaction, and only 4 percent of fraternal twin pairs were concordant (Slater & Shields, 1969). In other words, if one member of an identical twin pair was diagnosed as suffering from anxiety reaction, the chances were slightly better than 4 in 10 that the person's twin would be similarly diagnosed, but for fraternal twins the chances were only 4 in 100. Since identical twins have identical genotypes, while fraternals have no more genes in common than do brothers and sisters who are not twins, the higher concordance for identicals may reflect their genetic "sameness." Of course, it is also possible that identicals are treated much more alike than fraternals, and therefore the higher concordance of anxiety could reflect environmental rather than genetic similarity. It seems unlikely, though, that genetic factors are not implicated, in view of the extremely large disparity in concordance between identical and fraternal twins.

Somatoform Disorders

Somatoform disorders involve physical symptoms ranging from a vague sense of weakness or pain to loss of sensation and paralysis. The distinguishing feature of such symptoms is that they occur in the absence of any known organic pathology. *Conversion disorder* is a somatoform disorder that has received a great deal of attention since before Freud's time. Freud based much of his psychoanalytic theory upon case histories of people (mostly women) suffering from conversion disorders.

Conversion disorder was called *hysteria* in the past, and it includes a variety

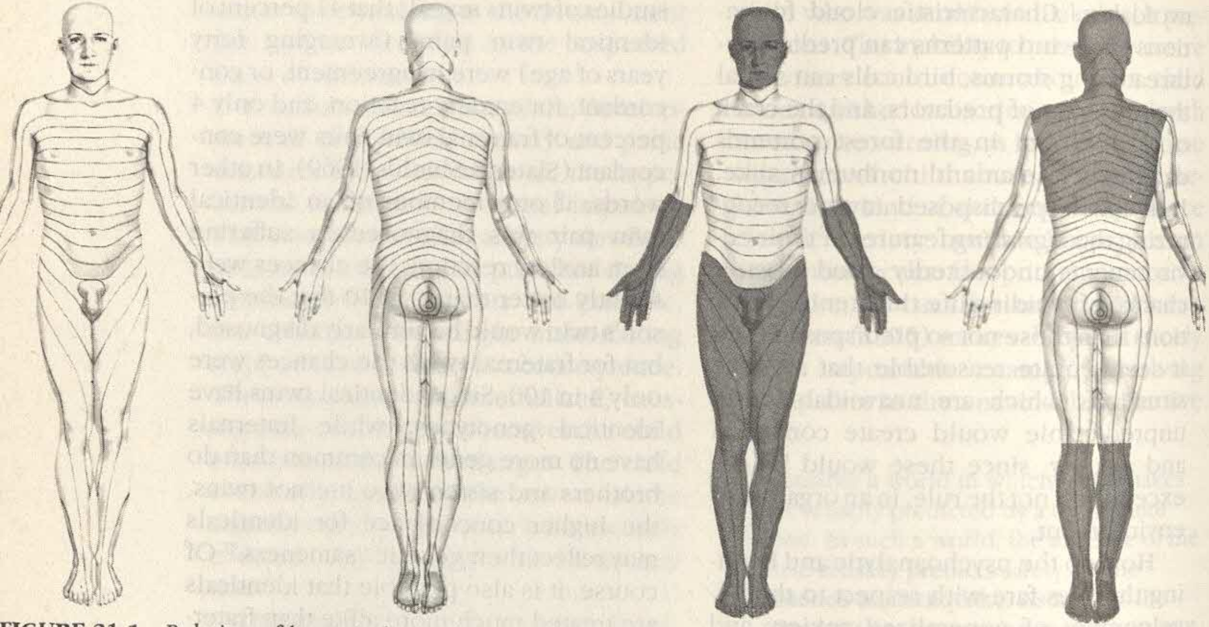


FIGURE 21.1 Relation of hysterical anesthesias to patterns of neural innervation of the skin. The colored portions of the two figures on the right show locations of typical anesthesias in hysterical patients. The two figures on the left show normal patterns of neural innervation. The anesthesias illustrated cannot be explained anatomically.

of possible symptoms: for example, paralysis, speech disturbances, epileptic-like seizures, muscular contractions and twitches, disturbances in vision or hearing, loss of sensitivity to stimulation of the skin, tingling sensations, coughing spells, and simulation of conditions such as appendicitis, tuberculosis, and pregnancy. Again, it is important to note that there is no apparent physical reason for such symptoms, but there usually are psychological stressors present that are presumed to serve as immediate causes of these symptoms (Figure 21.1).

Psychoanalytic explanations of conversion disorders center around unresolved Oedipal desires and conflicts. Presumably, these Oedipal phenomena are repressed during childhood because they are too anxiety-provoking to contend with at the conscious level of personality. A conversion disorder may result if aspects of the repressed material begin to surface into conscious awareness at a later time. In this instance, the anxiety that has been reawakened is *converted* into a bodily ailment in order to keep it from overwhelming the individual, according to psychoanalytic theory.

Learning explanations of conversion disorders often emphasize the importance of observational learning (for instance, Ullman & Krasner, 1975). One idea is that the person suffering from conversion disorder is *imitating* how he or she imagines a person suffering from real physical disorders would act. It is important to note that this is not faking, in the sense of trying to deceive someone else. Rather, the person has internalized the imitation and apparently experiences the bodily symptoms.

Evidence pertaining to conversion disorders is often consistent with the notion that learning, as well as the environment in general, plays an important role in the particular pattern of symptoms that appears. Conversion symptoms often seem to be contagious, as in spells of yawning and fainting, and there is evidence that parents of those suffering from certain conversion disorders often have had an illness involving the same organ system (Mucha & Reinhardt, 1970). In addition, the particular conversion symptoms vary depending upon the historical period. For example, fainting and certain kinds of "anesthesias" were much more common in the nineteenth century than they are nowadays. Finally, symptoms also vary with the degree of medical sophistication people have. Currently there is no evidence of a significant genetic involvement in conversion disorders.

It is quite possible that some cases of actual physical illness are *incorrectly* diagnosed as conversion disorders. For example, Slater and Glithero (1965) found that 60 percent of a sample of patients originally diagnosed as having conversion symptoms had died or developed clearly recognizable diseases of the central nervous system several years after the original diagnosis. At the very least, these data argue for persistent and detailed physical examination before organic factors are ruled out in the causation of physical ailments.

Dissociative Disorders

Dissociative disorders include psychogenic amnesia, psychogenic fugue, and multiple personality. **Psychogenic amnesia** refers to a loss of memory, especially memory for personal experiences and identity. The fact that only certain memories are lost and that there is no apparent physical injury or disease differentiates psychogenic amnesia from other kinds of memory loss.

Fugue refers to physical flight or withdrawal from a situation that often accompanies psychogenic amnesia. For example, a man may not show up at home or work for days. Later he "wakes up" in a strange place, completely unaware of the circumstances that led to his being there. During the fugue, the afflicted person may engage in normal behaviors, but often these behaviors are not recalled.

Multiple personality is the most dramatic and also the rarest kind of dissociative disorder. A person suffering from multiple personality develops two or more distinct personalities, sometimes very early in childhood. The different personalities usually appear to manifest conflicting motives; for example, one personality may be driven by pleasure-seeking impulses while another considers the welfare of others to be of prime importance.

A classic case of multiple personality is that of Eve White, described in the book *The Three Faces of Eve* (Thigpen & Cleckley, 1957), and dramatized in the motion picture of the same name. Eve White was a twenty-five-year-old woman who sought therapy for a variety of symptoms, including intense headaches that were often followed by blackouts. She appeared to be a dignified, somewhat withdrawn, conventional person who experienced a great deal of frustration. During the course of a therapeutic session Eve White "changed personalities." On one occasion, she suddenly appeared to be overwhelmed by pain and, after a period of silence, a smile came to her lips. She took on a completely different demeanor than before: outgoing, playful, uninhibited, carefree, adventurous, mischievous, and seductive. This new personality announced herself to be "Eve Black," and was very much aware of the existence of Eve White, whom she had little regard for. The two Eves appeared to be opposites in terms of appearance, personality, and motivations. After approximately eight months of therapy, in which the two Eves alternated, a third personality emerged, who called herself Jane. Jane seemed more mature and better adjusted than either Eve White or Eve Black. Finally, following a traumatic incident in which Jane recalled being forced to kiss her dead grandmother as a child of five, a fourth personality, Evelyn, appeared. Evelyn seemed to represent an integration of the previous personalities.*

Dissociative symptoms can be extremely dramatic, as in cases of multiple personality. The reasons some individuals react to stress in these extreme ways are not known, but the psychoanalytic explanation follows along the same lines as for conversion disorders. According to the psychoanalytic view, a traumatic experience awakens anxiety, usually Oedipal, that is too threatening for the person to handle at the conscious level of personality. But rather than converting the anxiety into bodily symptoms, the ego defends the afflicted person by *repressing* it, thus dissociating the person from it. The repression is not restricted to the anxiety, however; it can be massive in dissociative disorders, involving a loss of identity or an unawareness of certain aspects of the personality.

In contrast to psychoanalytic theory, the learning approach stresses the development of escape or avoidance behaviors as a result of reinforcement of these behaviors. For example, the forgetting that occurs in psychogenic amnesia may reduce stress and therefore be reinforcing. In cases of multiple personality, the individual may adopt the behavior patterns of someone else, using observational learning. Presumably, if stress is reduced by doing this, the individual may continue to behave as an entirely different personality. It is difficult to know where an observational learning explanation may leave off and a *cognitive* explanation begin, since much observational learning obviously involves cognitive components (Bandura, 1977).

Psychosexual Disorders

Few classifications of abnormal behavior receive as much societal analysis as the psychosexual disorders (Table 21.5). Almost everyone has an opinion about what constitutes a sexual disorder, whether the criteria are philosophical, theological, biological, psychological, sociological, legal, political, or "commonsense." Note that missing from the DSM-III list of psychosexual disorders are homosexuality, masturbation, and sexual promiscuity. Of these, the most controversial topic is homosexuality, which at one time was listed in DSM as a sexual disorder. In 1973, however, the board of trustees of the American Psychiatric Association voted to remove it from the list and consider it an *alternative* sexual pattern, not a disorder.

Exclusive homosexuality is relatively rare, is not approved in many societies, and is not biologically adaptive. Nevertheless, it is not synonymous with subjective distress or psychological handicap. Groups of homosexuals not in treatment or not charged with a sexual offense have been shown to be as well adjusted overall as groups of heterosexuals. There are some indications of lowered self-confidence and reduced happiness, but these may be natural reactions to societal discrimination. Those who favor the idea that homosexuality

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* There is evidence that Evelyn was not the final personality to emerge; Evelyn may have been merely the fourth of twenty-one different personalities (Calhoun, 1977).

TABLE 21.5 DSM-III Classification of Major Psychosexual Disorders

Type	Examples
Gender identity disorders	Transexualism (desire to live as member of the other sex)
Paraphilias	Fetishism (use of nonliving objects as means of sexual gratification)
	Transvestism (persistent wearing of female clothes by males for sexual stimulation)
	Exhibitionism (exposure of genitals to a stranger for sexual stimulation)
	Sexual masochism (sexual excitement produced in an individual by his or her own suffering)
Psychosexual dysfunctions	Inhibited sexual desire
	Inhibited orgasm
	Premature ejaculation

itself should not be considered a disorder argue that homosexual behavior has been with us throughout recorded history, and in certain societies, such as early Greece and Rome, homosexual practices were condoned. Also, homosexual behavior is not an either-or affair. The classic study by Kinsey et al. (1948) indicated that a substantial proportion of a sample of white males reported having had homosexual experiences at some point in their lives. Coleman (1976) summarized the Kinsey findings as follows:

13% had reacted erotically to other males without having overt homosexual experiences after the onset of adolescence.

37% had had homosexual experience to the point of orgasm after the onset of adolescence.

50% of those who remained unmarried to the age of 35 had had overt homosexual experience to the point of orgasm since the onset of adolescence.

18% revealed as much of the homosexual as the heterosexual in their histories.

8% engaged exclusively in homosexual activities for at least three years between the ages of 16 and 55.

4% were exclusively homosexual from adolescence on (p. 590).

Homosexual behavior has also been observed in other animals. For example, Maier and Maier (1970) cite observations of such behavior in dogs, monkeys, apes, and dolphins kept in captivity.

The sexual patterns that *are* considered disorders in DSM-III include those listed in Table 21.5. Patterns that are *not* listed in DSM-III as disorders include rape, incest, masturbation, premarital and extramarital coitus, promiscuity, and prostitution, as well as homosexuality. Although these sexual behaviors *technically* may not be considered disorders, many clinicians would argue that homosexuality and at least two others—rape and incest—often involve disturbances in sexual orientation and development.

Even human sexual behavior generally regarded as normal is characterized by a great deal of variability, and so it should not be surprising that causal factors in the development of sexual disorders are difficult to pinpoint. Psychoanalytic views stress the importance of unresolved Oedipal conflicts and resulting anxiety. Learning views stress the associations made between certain sexual situations and positive reinforcement or punishment, or observational learning of deviant sexual patterns. In some cases of sexual disorder there may be hormonal or genetic influences that predispose the behavior. **Transexualism** seems a likely candidate for a biological explanation. Transexual persons identify with members of the opposite sex, and many of them feel so strongly identified in this fashion that they undergo sex-change operations.

The Neuroses: A Final Comment

Although neurotic behaviors usually are not severe enough to require prolonged hospitalization, they can sometimes be quite intractable. Many neurotics come to rely on their defensive behaviors so much, even when these behaviors are self-defeating, that it is difficult for them to give up these strategies. In addition, neurotics often know they are neurotic, and this can be a great conversation piece, a way of eliciting attention from others, or a way of controlling others. By giving up patterns of maladjusted behavior, the neurotic risks giving up a source of distinction, attention, and power. Nevertheless, many persons suffering from neurotic behaviors do recover. In fact, even without therapeutic intervention, improvement rates are estimated to be between 40 and 50 percent (Bergin & Lambert, 1978).

Psychoses

The **psychoses** represent the most serious and sometimes the most bizarre of psychological disorders. Unlike neurotics, psychotics nearly always require hospitalization or close psychiatric and psychological supervision. We will review two major categories of psychotic behavior: the *major affective disorders* and *schizophrenia*. Each of these disorders is marked by a loss of touch with reality, often to the point that the psychotic person cannot function within the family or the rest of society without a great deal of assistance.

In discussing theoretical explanations of psychotic behavior, we will emphasize biological, cognitive, and learning accounts. Psychoanalytic theory, even according to some psychoanalysts, appears better suited to explaining the origins of neuroses than of psychoses. And humanistic-existential accounts also seem more appropriate for understanding anxiety and certain other neurotic conditions than for understanding psychoses.

Major Affective Disorders

There are two kinds of **major affective disorders:** bipolar disorder and major depression. In the past, **bipolar disorder** was called *manic-depressive psychosis,* a more descriptive term. In one manifestation of bipolar disorder, a person may show signs of extreme excitability, agitation, elation, irritability, and accelerated speech and motor activity. The person may require little sleep, and may act in some ways as though high on amphetamines or cocaine. There may be **hallucinations,** hearing or seeing things that others don't, and *delusions,* false ideas of grandeur or persecution. All of these symptoms characterize one of the poles of bipolar disorder—*mania* or the manic expisode.

Persons who experience a manic episode are usually diagnosed as having a bipolar disorder because it is statistically quite likely that they will also swing to the opposite pole and experience severe depression at some point in their lives. Thus bipolar disorder implies mania alternating with depression. Sometimes the alternation between these extreme mood states takes place within a relatively short period of time. In other cases bipolar individuals may go for weeks or months in one or the other mood state, with the depressive phase usually lasting longer than the manic phase.

Major depression might be considered an extreme version of neurotic depression discussed earlier in the chapter. The symptoms of major depression can be wide-ranging, but the major features that differentiate major depression from neurotic depression are *severity* of symptoms and *loss of contact* with reality, as evidenced by confused thinking and possible delusions and hallucinations. These symptoms are summarized by Martin (1981).

> All zest for living is lost. Feelings of pleasure and joy give way to sadness or to a nonfeeling state of emotional numbness. Spontaneous initiative in activities, whether in work or play, yield to passivity and apathy. Interest in food or sex is lost or turns into a revulsion against these biological needs. Attitudes of self-acceptance and hopefulness are twisted into attitudes of self-blame and despair. The person thinks, "What's the use?" "It's all my fault," "Things will never get better." Sleep does not come at night, and bodily concerns can grow into preoccupation with fears of disease. And ultimately even the desire to live may be replaced with a wish to die (p. 343).

There are also some important differences between major depression and the depression experienced by those with bipolar disorder. Those suffering from major depression seem to experience more anxiety within their depressive episodes than do bipolar persons. In addition, the average age of onset for major depression is in the forties, later than for depressions that are part of bipolar disorder, whose onset occurs most often in the thirties. Finally, there is less support for genetic involvement in major depression than in bipolar disorder.

At one time or another, most people experience symptoms of depression. However, some individuals suffer from forms of depression that pose a serious psychological handicap.

Explaining Affective Disorders

Learning explanations of depression, including neurotic depression, traditionally have hypothesized a lack or withdrawal of positive reinforcement as responsible for depression. This explanation seems quite plausible in cases of depression associated with separation from a loved one, rejection by friends, unemployment, an unsatisfying job, or other identifiable circumstances. However, this particular learning theory does not explain depression that seems to arise in the absence of any identifiable stimulus, and it would seem hard pressed to account for depression so intense that it leads to suicide.

A more recent learning (and cognitive) formulation is the "learned helplessness" account mentioned earlier in connection with anxiety. According to this view, depression results from perceived lack of control over the environment. Although the initial reaction may be one of anxiety, prolonged exposure to unavoidable and unpredictable trauma may lead to depression, despair, and possibly suicide. Human studies show that depressed individuals are more likely than are nondepressed persons to perceive they have less control than they actually do, and they also seem to be more adversely affected by *loss* of control (Seligman, 1975).

Another cognitive interpretation of depression has been proposed by Aaron Beck (1967, 1976). Beck's notion is that depression arises from negative attitudes about oneself and a negative bias in interpreting normal everyday occurrences. According to his view, the basic premise of the depressed person seems to be one of self-devaluation, and all events are perceived in this light. For example, if someone honks at a depressed woman who is backing out of a parking place, she concludes that she is a "hateful person." If her husband gets angry at her for being late, she concludes that she is not attractive anymore and worthless in his eyes.

It seems unlikely that all cases of depression, and especially bipolar disorders involving mania and depression, can be explained adequately if biological factors are ignored. Results of twin studies suggest there may be a genetic basis for bipolar disorders. In general, comparisons of identical and fraternal twins show a higher concordance for major affective disorders among identicals. These results are especially clear in the case of bipolar disorders, but findings from recent family studies raise the possibility of genetic influence on unipolar depression as well (Henderson, 1982).

There is also evidence of biochemical correlates of bipolar disorders. Decreased levels of the neurotransmitters serotonin and epinephrine have been associated with bipolar depression. Increased levels of norepinephrine often accompany manic episodes. In individuals who alternate from depression to mania, norepinephrine levels have been seen to rise *prior* to the onset of the manic symptoms (Bunney, Goodwin, & Murphy, 1972). Thus changes in neurotransmitter levels may be a cause rather than an effect of the manic symptoms.

Physiologically, it makes good sense that significant depletion of a neurotransmitter could cause depression, since neurotransmitters are responsible for the conduction of a nerve impulse from one neuron to another. It is also logical that an excess of neurotransmitter could result in the hyperactivity and agitation that is associated with mania, because in that case perhaps too many nerve impulses are being conducted.

Schizophrenic Disorders

The symptoms of schizophrenia are the most bizarre and disabling of all the psychoses. A diagnosis of schizophrenic disorder nearly always means some period of hospitalization; persons diagnosed as schizophrenic constitute about 20 percent of first admissions to mental hospitals, and about 50 percent of the resident hospital population. It is estimated conservatively that approximately 1 percent of the population is schizophrenic, which translates to over two million people in the United States.

Schizophrenic behavior involves disturbances in language and thought, perception, motor behavior, affect, and social behavior, although not every schizophrenic shows severe disturbance in all four areas. The major impressions schizophrenic behavior convey are of being out of touch with reality, socially inappropriate, cognitively disoriented, and emotionally distorted. Each area of disturbance in schizophrenic behavior is characterized more completely in Table 21.6.

Schizophrenia is subdivided into several different types, of which the most common is **paranoid schizophrenia.** The paranoid type is characterized by delusions of grandeur and persecution, sometimes accompanied by hallucinations, all of which become the central focus of the person's life. Hearing voices and obeying their commands are not uncommon in cases of paranoid schizophrenia. These delusions, and the compulsion to act on them, can be dangerous and even lead to homicide. The following conversation between a doctor and a paranoid schizophrenic patient illustrates the unrealistic and delusional nature of thinking in a case of paranoid schizophrenia:

DR.: What's your name?

PT.: Who are you?

DR.: I'm a doctor. Who are you?

PT.: I can't tell you who I am.

DR.: Why can't you tell me?

PT.: You wouldn't believe me.

DR.: What are you doing here?

PT.: Well, I've been sent here to thwart the Russians. I'm the only one in the world who knows how to deal with them. They got their spies all around here though to get me. But I'm smarter than any of them.

DR.: What are you going to do to thwart the Russians?

PT.: I'm organizing.

DR.: Whom are you going to organize?

PT.: Everybody. I'm the only man in the world who can do that, but they're trying to get me. But I'm going to use my atomic bomb media to blow them up.

DR.: You must be a terribly important person then.

PT.: Well, of course.

DR.: What do you call yourself?

PT.: You used to know me as Franklin D. Roosevelt.

DR.: Isn't he dead?

PT.: Sure he's dead, but I'm alive.

DR.: But you're Franklin D. Roosevelt?

PT.: His spirit. He, God, and I figured this out. And now I'm going to make a race of healthy people. My agents are lining them up. Say, who are you?

DR.: I'm a doctor here.

PT.: You don't look like a doctor. You look like a Russian to me.

DR.: How can you tell a Russian from one of your agents?

PT.: I read eyes. I get all my signs from eyes. I look into your eyes and get all my signs from them.

DR.: Do you sometimes hear voices telling you someone is a Russian?

TABLE 21.6 Major Areas of Disturbance in Schizophrenia

Area	Examples
Thinking	Delusions (irrational beliefs—e.g., that others are attempting to harm one or control one's thoughts) Loose associations (unconnected thinking that may be manifested as incoherent speech)
Perception	Hallucinations (especially auditory in nature)
Affect	Flattening of emotion or inappropriate emotion
Motor behavior	Decreased motor activity; excessive motor activity; bizarre postures and movements
Social behavior	Extreme withdrawal from social situations

PT.: No, I just look into eyes. I got a mirror here to look into my own eyes. I know everything that's going on. I can tell by the color, by the way it's shaped.

DR.: Did you have any trouble with people before you came here?

PT.: Well, only the Russians. They were trying to surround me in my neighborhood. One day they tried to drop a bomb on me from the fire escape.

DR.: How could you tell it was a bomb?

PT.: I just knew (Coleman, 1976, p. 300).

In cases of other kinds of schizophrenic reactions conversation may be impossible, even illogical conversation. For example, persons diagnosed as suffering from **catatonic schizophrenia** may spend hours in a motionless, withdrawn, mute, trance-like state.

Explaining Schizophrenic Disorders

Schizophrenia represents such a dramatic departure from the norm, and includes disturbances in so many areas of functioning, that any single theory we have discussed seems inadequate in specifying causes. The psychoanalytic approach stresses the unbridled release of id impulses and regression to earlier stages of development. Learning explanations emphasize instrumentally learned escape and avoidance responses. Such responses become reinforcing in themselves, and the schizophrenic slips into a perpetual "escape" into his or her own fantasy world. Also, once the abnormal behaviors have emerged, the schizophrenic may be inadvertently reinforced by family members, friends, and mental health professionals who attend more to the abnormal manifestations than to lucid ones.

TABLE 21.7 Risk of Schizophrenia for Relatives of Schizophrenics

Relationship	Number in Sample	Relatives of Schizophrenics Who Also Show Schizophrenic Symptoms (%)
Spouses	194	2.1
Identical twins	261	45.6
Fraternal twins	329	13.7
Siblings	8817	8.4
Children	1578	11.3
Half-sibs	499	3.4
Nieces and nephews	3966	2.7
Grandchildren	739	2.8
First cousins	1600	1.6

Source: Based on Gottesman & Shields (1982), and Rao, Morton, Gottesman, & Lew (1981). Cited in Henderson (1982).

Despite many serious attempts to understand schizophrenia in terms of either psychoanalytic or learning principles, the evidence to date seems to favor a biological explanation, at least for the *origins* of schizophrenia. As is the case for bipolar affective disorder, twin studies invariably show higher concordance for schizophrenia among identical twins than among fraternals (see Table 21.7). In addition, there are now a number of studies showing that the biological parents of adopted schizophrenic children are more likely to be schizophrenic or exhibit schizophrenic tendencies than are the foster parents of such children (Heston, 1966; Kety, Rosenthal, Wender, Schulsinger, & Jacobsen, 1976). These findings are impressive because the more recent studies have shown this relationship to hold even when the children were separated from their biological parents very early in life, and to hold specifically for schizophrenia as opposed to other disorders. The fact that adopted schizophrenic children resemble their biological parents in terms of the disorder more than their foster parents, with whom they have spent the majority of their lives, constitutes strong evidence for a genetic influence on schizophrenia.

If genes are involved in schizophrenia, and the evidence suggests they are, then how does genotype influence the development of schizophrenia? And what role does the environment play in producing this psychotic disorder?

Although we do not know for sure which genetic mechanisms are involved in schizophrenia, it appears that genetic influence is not direct; that is, it is unlikely that there are genes that code directly for the development of schizophrenic behavior. Rather, what may be inherited is a tendency or predisposition for schizophrenia. Whether a person who inherits this tendency will become schizophrenic depends upon the environment. If there is a low level of stress in the environment, or of particular kinds of stress, then even an individual with an inherited predispostition for schizophrenia may not develop the disorder. If the right kinds and amounts of stressors are present in the enviroment, then such a person might well become schizophrenic. On the other hand, the chances of a person developing schizophrenia *without* the inherited predisposition is low, even if the person was raised under stressful conditions. According to this hypothesis, both genetic influence and the environment are important in understanding the development of schizophrenia.

The terms *genetic tendency* and *genetic predisposition* are extremely vague. What does it mean to have an inherited predisposition for schizophrenia? What kinds of genetically coded structural or functional characteristics of the nervous system might produce a "high-risk" individual with respect to the development of schizophrenia? Answers to these questions are a long way from being definitive, but we do have some clues. A number of studies have shown that schizophrenics tend to be physiologically overreactive or underreactive to various kinds of stimuli (Mednick, Schulsinger, & Garfinkle, 1975; Venables, 1977; Venables & Bernstein, 1983). *Overreactive* schizophrenics tend to show no habituation of autonomic nervous system arousal to repeated presentation of an auditory stimulus; they continue to respond with a high level of autonomic arousal. *Underreactive* schizophrenics tend to show little or no arousal to even *one* presentation of the stimulus. Neither of these patterns characterizes nonschizophrenic individuals, who show the highest level of arousal to the first presentation of the stimulus, and lower arousal with additional presentations.

What is most interesting is that the pattern of autonomic *overreactivity* has been demonstrated to be a defining feature of adolescents who are *at risk* for schizophrenia, and who eventually become schizophrenic. In other words, the pattern of overarousal *preceded* the onset of schizophrenia in these individuals, but was not observed in high-risk or low-risk control subjects who did not become schizophrenic. ("High-risk," as used here, means that the individual has a schizophrenic parent.)

The autonomic overarousal pattern of schizophrenics and preschizophrenics fits nicely with other evidence that schizophrenics are highly distractible, and seemingly unable to keep from responding to external and internal stimuli that would not elicit an attentional response from nonschizophrenic persons. The underarousal pattern may be an adaptive alternative to overarousal — a strategy that allows the schizophrenic to escape overstimulation.

In addition to the evidence concerning autonomic reactivity, some studies have linked schizophrenia to an oversensitivity of certain nerve cells that are activated by the neurotransmitter **dopamine.** In essence, the dopamine hypothesis states that more neurons in the schizophrenic are firing, or neurons are firing more often, than would be the case for nonschizophrenics. Characteristically, these neurons are "overactive" because they are hypersensitive to apparently normal amounts of dopamine (Davis, 1978). Evidence consistent with the dopamine hypothesis includes the finding that the phenothiazines, drugs that suppress certain symptoms of schizophrenia, apparently also inhibit neurons that normally respond to dopamine. Thus, in effect, the phenothiazines reduce dopamine-related neural activity, perhaps to levels that characterize nonschizophrenics. However, it appears that the phenothiazines work "too well" in some cases. Some schizophrenics receiving this treatment show motor impairments resembling symptoms of Parkinson's disease, a disorder that is characterized by a deficiency in dopamine-related neural activity (Lahey & Ciminero, 1980).

Perhaps we are on the verge of a breakthrough in understanding the biological basis of schizophrenia. Certainly it seems as though the schizophrenic patterns of autonomic over- and underarousal, the attentional problems, the overactivation of dopamine-sensitive neurons, and the evidence for a genetic influence on schizophrenia all fit together and may be linked causally. Yet we must be cautious. For example, the dopamine hypothesis, although attractive in the late 1970s, has received mixed reviews recently (Coleman, Butcher, & Carson, 1984). Martin (1981) notes the need for caution here:

> The field of schizophrenia research is littered with the abandoned wrecks of once-promising theories. Excessive dopaminergic activation may yet turn out to be a secondary aspect of the neurophysiology of schizophrenia. Even if it plays a primary causative role, there still remains the task of understanding how the disturbed dopaminergic system produces the symptoms of schizophrenia. There are many possibilities since, for example, dopamine neurons are involved in various cortical, brainstem, and limbic systems that affect motivation, emotion, and attentional processes. At some point the behavioral research on attentional deficits and the physiological research indicative of over- and underarousal will converge with the biochemical research to complete our understanding of the biological side of schizophrenia. And very likely this final picture will include the locus of those biochemical or neurophysiological dysfunctions that are genetically transmitted. We are not there yet. We may be close or the goal may elude us for some time to come (p. 302).

Our picture of the causes of schizophrenia would not be complete without acknowledging the presence of environmental stressors that may precipitate a schizophrenic breakdown or increase and maintain schizophrenic behavior. There are many indications that the families of schizophrenics often constitute a pathological environment. For example, patterns of communication in schizophrenic families deviate considerably from normal family patterns. Such patterns are characterized by "loose" thinking and vague statements, as well as so-called double-bind communications. The double bind is a situation involving contradictions from which there is no way out for the victim. A child greets his mother with physical affection, only to be rebuffed by her for it. When the child ceases his display of affection, his mother says, with obvious hurt in her voice, "What's the matter, don't you love me anymore?" Obviously, a heavy dose of these sorts of mixed messages could be a great source of frustration and stress, and result in withdrawal by a child predisposed toward schizophrenic patterns of behavior.

In addition to communication problems, families of schizophrenics tend to have a great deal of marital discord. In one study of fourteen schizophrenic children and their families the investigators failed to find a single family that could be described as reasonably well adjusted. In many of these families marital separation was continually threatened, with consistent undermining of the worth of one partner by the other. The majority of the families had at least one parent who was either psychotic or showed psychotic tendencies (Lidz, Cornelison, Terry, & Fleck, 1958).

It is difficult to know for sure whether the abnormal family patterns cause schizophrenia in the child, are a reaction to the disturbances produced by the child, or are independent of the child's schizophrenic behavior. But there is evidence that some of these familial problems *precede* the onset of schizophrenic symptoms in the child (Waring & Ricks, 1965). It seems quite conceivable that such stresses could bring about schizophrenia in a child genetically predisposed for this disorder. It is also plausible that the development of schizophrenic behavior in a child could further increase levels of stress experienced by the other family members. Any such increase in familial stress might in turn maintain or even increase the child's schizophrenic symptoms. Clearly, stresses in the environment as well as biological influences are important variables in the development of schizophrenia.

Other Behavioral Disorders

There are a number of behavioral disorders that are not classifiable as neuroses or psychoses. Space limitations do not allow elaboration of any of these, but at least one—antisocial or psychopathic personality—deserves mention.

Antisocial personality is classified in DMS-III as a type of *personality disorder,* a category distinct from the neuroses and psychoses. Major characteristics of antisocial personalities include a poorly developed conscience, lack of anxiety or guilt feelings over wrongdoing, low tolerance for frustration, impulsive behavior, irresponsibility, apparent charm and optimism, rejection of authority, inability to profit from mistakes, and inability to feel empathy for others and to maintain close personal friends. Perhaps the feature that best differentiates the antisocial personality from the neurotic is lack of anxiety. Compared to a psychotic individual, the antisocial personality appears to have considerably more contact with reality, and is unlikely to require hospitalization.

Antisocial personalities, commonly called psychopaths or sociopaths, are more often males than females, and seem to have a good deal of difficulty abiding by the law or by commonly accepted principles of morality. According to Coleman (1976), "The category called antisocial personality includes a mixed group of individuals: unprincipled businessmen, shyster lawyers, quack doctors, high-pressure evangelists, crooked politicians, imposters, drug pushers, a sizeable number of prostitutes, and assorted delinquents and criminals" (p. 370).

Ferdinand Waldo Demara, Jr., the "great imposter," manifested symptoms that fit the diagnostic category of antisocial (psychopathic) personality. Using fraudulent credentials, Demara posed as a college dean, a physician in the Royal Canadian Navy, and a prison warden. Even though he had no medical training, Demara at one point in his life performed successful surgery, and was hailed as a heroic physician during the Korean War.

No single cause has been identified for the antisocial personality. There is some evidence to suggest that such individuals need more stimulation than others (Fenz, 1971) and are less easily aroused by aversive stimuli (Eysenck, 1960). There is also some suggestion of a genetic basis for antisocial behavior that results in criminal activity. For example, property crimes of individuals raised by foster parents are more highly correlated with criminal conviction rates of their *biological* parents than with those of the adoptive parents (Mednick, Gabrielli, & Hutchings, 1984). Environmental factors such as parental loss, rejection, and inconsistency; faulty parental models and interactions; and depriving social conditions have also been implicated in antisocial personality (Coleman, 1976).

Why Abnormal Behavior?

Abnormal behavior is sometimes characterized as *maladaptive* behavior, behavior that interferes with an individual's survival, growth, or fulfillment, and with the well-being of society (Coleman, 1976). Used in a strictly biological sense, the term *maladaptive* means anything that reduces fitness; a maladaptive characteristic is one that reduces the chances for individual survival and reproduction. But are the various categories of abnormal behavior, as outlined in this chapter and more completely in DMS-III, *always* maladaptive? That is, do they necessarily interfere with individual survival and reproduction? Although this may seem to be the case in many instances, and certainly was for some of those tortured as witches in the past, it does not have to be this way. In fact, certain behaviors called abnormal may once have had, or may now have, *adaptive* consequences. For example, certain neurotic disorders may be exaggerated forms of reacting to stress, and the capacity for such exaggerations may have been adaptive for our hominid ancestors. Reacting to potentially threatening stimuli with extreme fear and trepidation, or to things that have occurred close in time or space to the threatening stimuli (as in phobias), may have been important motivators for escape from or avoidance of predators, other harmful animals, and dangerous situations. For groups adapted to environments characterized by a great deal of predator or competitor unpredictability, it may have made good sense to spend a lot of time "on edge," reacting to even slight changes in the environment with fear and a readiness for "flight or fight" (as in generalized anxiety disorder). Of course, in modern societies where survival is not being threatened on a day-to-day basis, such tendencies would stand out as exaggerated and inappropriate.

Even if we were to assume that various neurotic behaviors had no adaptive value for our ancestors, it seems reasonable to hypothesize that such behaviors may contribute to survival, at least indirectly, in the present. One possible example of this sort of thing was related by a speaker at a recent psychology workshop attended by one of the authors. The case involved a university student who developed symptoms of physical illness, including blindness, shortly before final exams. She was granted "incompletes" in her courses, recovered in a few weeks, later took the finals, and maintained her A average. By developing what appears to have been a conversion disorder, she reduced the stress that had resulted, at least partly, from lack of study that term, gained time, and preserved her academic record.

We are not suggesting that all or most behavioral disorders have adaptive consequences. But to think that behavior we call abnormal is always maladaptive, at least in the Darwinian sense of the term, may be a mistake. Hoyenga and Hoyenga (1984) underscore our point and offer additional speculations:

> The survival of genes that create a predisposition for abnormal emotional responses can . . . be understood from an evolutionary perspective. . . . There are several reasons why evolution would not have caused these genes to disappear entirely from human hereditary potential. First, these genes would have seriously impaired the survival only of individuals who grew up in "abnormal" and therefore rare environments. Genes that are rarely expressed can be selected *against* only very slowly. Second, the same genes might have conferred some adaptive advantages as well as predispositions to emotional problems. One frequently cited example is the possible association of the schizophrenic genetic predisposition with enhanced creativity. . . . Third, the ability to visibly display distress in the form of depression or anxiety might have elicited caretaking behavior from other organisms, especially from relatives who could increase their inclusive fitness by such behavior. Thus, the ability to visibly display the effects of being under stress could be adaptive, eliciting caretaking and thereby facilitating survival . . . (p. 186).

Modifying Abnormal Behavior

22

Biological Therapies

Psychoanalytic Therapy

Learning Therapies

Humanistic-Existential Therapies

Psychological Therapies in Perspective

Modifying Abnormal Behavior: Evolutionary Considerations

Supplement 1 A Humanist-Behaviorist Dialogue

Chapter Preview

Contemporary therapies for abnormal behavior have developed hand in hand with scientific theories of personality and abnormal behavior. These include biological therapies, psychoanalytic therapy, learning therapies, and humanistic-existential therapies.

Major *biological therapies* are chemotherapy, which involves the use of drugs to treat behavioral disorders, and *electroshock therapy* (EST), which is used mainly in the treatment of severe depressions. *Psychosurgery* is also a biological therapy, but one that produces questionable and irreversible results.

Sigmund Freud pioneered *psychoanalytic therapy,* the first "talk therapy" designed to get a person to reexperience repressed childhood conflicts and thereby reduce anxiety. There are four basic psychoanalytic methods: *free association, dream interpretation, analysis of resistance,* and *analysis of transference.* It is difficult to evaluate the effectiveness of psychoanalytic therapy. The few systematic evaluation studies that have been carried out reveal no major advantage for psychoanalysis over other forms of therapy.

Learning therapies are based upon the assumption that abnormal behaviors are learned and maintained according to principles of classical conditioning, instrumental and observational learning, and cognitive processes. *Classical conditioning therapies* include *flooding,* a type of extinction; *desensitization,* a type of counterconditioning; and *aversive conditioning,* another type of counterconditioning. *Instrumental learning therapies* use *positive reinforcement, extinction,* and *punishment* to bring about behavioral change. *Observational learning therapies* are based upon imitative learning, and can provide a very rapid means of behavior change.

There is a trend in learning therapies to go beyond overt behavior and include *cognition* as a legitimate focus for change. A widely cited example of therapies that attempt to restructure cognitions is *rational emotive therapy,* developed by Albert Ellis.

Humanistic-existential therapies differ substantially from learning and psychoanalytic therapies. They are less formal, and are based more upon philosophical considerations than scientific ones. Generally these therapies are concerned mainly with *changes in feelings* rather than with cognitive or behavioral changes. Two such therapies include *client-centered therapy,* developed by Carl Rogers, and *existential therapy,* advanced by Victor Frankl and Rollo May, among others.

Many problems are involved in evaluating therapeutic effectiveness. However, based on the evidence to date, it would appear that psychological therapy of any kind is, in general, better than no therapy. Which kind of therapy is most effective depends upon a number of variables. The chapter concludes with a discussion of therapies from an evolutionary perspective.

The supplement to this chapter presents a hypothetical conversation between a humanistic therapist and one who has a behavioristic outlook. The dialogue illustrates some of the basic differences as well as similarities between these two therapeutic perspectives.

History reveals continuous attempts to eradicate abnormal behavior. In the distant and not so distant past many of the attempts centered around the concept of demonology. If bizarre manifestations of behavior are due to demonic possession, then the "logical" therapy would involve ridding the afflicted person of the responsible demons. And so it went: Such "therapies" ranged from chipping away at the skull to release the evil spirits to applying the mysterious and complicated rituals of exorcism. In some cases physical torture and death were the ultimate therapeutic procedures.

Systematic rituals and prescriptions to deal with physical and mental illnesses are found in most cultures, primitive as well as technologically advanced. And there is evidence that remedies for mental problems may have existed in early human societies a million years or so ago.

Paleontologists, working with remnants of the Stone Age and later, hypothecate that bits of bone, teeth of animals,

> vertebrae of snakes found in amulet bags contained some magic force, some magic law, that contributed mental ease to their possessors. . . . That some type of practitioner, the shaman of the Bronze Age, used this magical aid through "dreams, controlled breathing, repetition," as well as amulets which embodied this force, seems reasonable. . . . Did early man borrow from his universe the concept of an external, all-powerful force, which could be harnessed to help his fellow man in pain and sorrow? The answer seems to lie in the concept of *mana,* a force that lay beyond the observable world, and which grew crops, avenged enemies, and healed the ill. This power, which we call supernatural, and the techniques to invoke it, which we call magical, probably represents the earliest form of psychotherapy.
>
> . . . The shaman or medicine man, by virtue of his special gifts and acquaintance with the supernatural world, was able to harness this force to heal the sick, divine the weather, and undo mischief. The shaman combined early religious concepts with a shrewd knowledge of his fellow man to become in Coon's words, "an all-purpose expert in human relations." Armed with the power of the *taboo* and his skill in invoking the Great Spirit or *mana,* it is assumed that the early medicine man served as physical and mental healer. "The shaman's profession," writes Coon, "not prostitution, is the oldest" (Bromberg, 1975, pp. 2–3).

Psychotherapy, although its roots extend back to magic and supernatural beliefs, finally escaped the world of superstition during the eighteenth and nineteenth centuries. Many contemporary procedures for modifying abnormal behavior develop hand in hand with scientific theories of personality and abnormal behavior. In other words, a particular form of therapy is often based upon a particular understanding of the way personality, normal and abnormal, develops and functions. (A notable exception is psychoanalysis, which developed first as a technique and later as a theory of personality.) So it should come as no surprise that there are as many different kinds of therapies as there are theories of personality.

Biological Therapies

Biological therapies are the province of medical practitioners, mainly psychiatrists. The most widely used biological therapy is *chemotherapy,* the use of drugs to treat abnormal behavior. Nondrug biological therapies include *electroshock therapy* and psychosurgery.

Chemotherapy

Chemotherapy has become a most popular treatment method during the past twenty-five years, and many feel that this is the most promising therapeutic avenue of all for certain disorders. The reasons for the proliferation of drug therapies, and for optimism regarding their potential, include breakthroughs in our understanding of neurotransmitter functioning in the nervous system and the success of various drugs in controlling certain behavioral disorders.

There are three major classes of drugs used in treatment: antipsychotic drugs, antianxiety drugs, and antidepressant drugs. Some are listed in Table 22.1. **Antipsychotic drugs** are major tranquilizers used to treat psychotic disorders, especially schizophrenia. The *phenothiazines* are the most widely used class of antipsychotic drugs, the most effective, and the least likely to produce severe short-term side effects. Among the

TABLE 22.1 Representative Drugs Used to Treat Certain Behavioral Disorders

Disorder	Drug Category	Generic Name	Trade Name
Anxiety	Minor tranquilizers	Chlordiazepoxide	Librium
		Diazepam	Valium
Major depression	Antidepressants		
	Tricyclics	Imipramine	Tofranil
		Amitriptyline	Elavil
	Monoamine oxidase (MAO) inhibitors	Isocarboxazid	Marplan
		Phenelzine	Nardil
Bipolar disorder	Antimanic drugs	Lithium carbonate	Lithonate
Schizophrenia	Major tranquilizers		
	Phenothiazines	Chlorpromazine	Thorazine
		Thioridazine	Mellaril
		Trifluoperazine	Stelazine
	Thioxanthenes	Haloperidol	Haldol

phenothiazines, *chlorpromazine* (Thorazine) and *trifluoperazine HCL* (Stelazine) have proved highly effective in calming tension, reducing disordered thought processes, and reducing motor hyperactivity associated with certain psychotic disorders. In addition, these drugs seem to have very specific effects, such as reducing or eliminating hallucinations and delusions, without affecting other functions. Thus the phenothiazines are not merely "super-tranquilizers" that reduce overall responsiveness; their action seems to selectively affect psychotic symptoms (van Praag, 1978).

Although the phenothiazines can be very effective in treating symptoms of schizophrenia, they are by no means a cure. Without the drug a schizophrenic may well relapse, and even with the drug improvement is not guaranteed. In addition, there are side effects that vary in intensity from person to person. These include dryness of the mouth, drowsiness, jaundice, fainting spells, and, with long-term use, tremors that resemble Parkinson's disease. Most of the side effects can be controlled to some extent by adjusting the dosage level. Finally, like many other drugs, the phenothiazines interact with alcohol, which poses a problem for noninstitutionalized patients.

Antianxiety drugs are minor tranquilizers used to treat neurotic disorders characterized by anxiety, and to treat nonneurotic individuals suffering from stress. These drugs may also be used as an adjunct to other therapies in treating psychotic disorders and alcoholism. Some of the more common antianxiety drugs include *meprobamate* (Miltown), *chlordiazepoxide hydrochloride* (Librium), and *diazepam* (Valium). These minor tranquilizers are preferable to barbiturates or other sedatives because they have fewer side effects and are less likely to lead to addiction. Nevertheless, these drugs do interact with alcohol, often greatly magnifying its effects. And severe withdrawal symptoms can occur following heavy use, including tremors, insomnia, convulsions, and hallucinations.

Antidepressant drugs are chemicals that are used to treat severe depressive reactions. Major classes of antidepressants include the MAO (*monoamine oxidase*) inhibitors such as *phenelzine* (Nardil) and *isocarboxazid* (Marplan), and the *tricyclic derivatives* such as *imi-*

pramine (Trofranil) and *doxepin HC1* (Sinequan). These agents can be extremely effective, but some can produce severe side effects and interact with other drugs and food substances. This is particularly true of the MAO inhibitors.

There are two other drugs that bear mentioning but do not fall under the three major classifications we have listed. These are *lithium carbonate* and *methylphenidate* (Ritalin). **Lithium carbonate** is used to treat *manic* symptoms that are part of the bipolar (manic-depressive) disorder. **Methylphenidate** has been used successfully to reduce symptoms of *hyperactivity* (as distinct from mania) in children.

All of the drugs we have described have been scientifically established as effective. That is, the drug has an effect that is measurably greater than that of a placebo or no drug. This does not mean that all patients suffering from schizophrenia, for example, benefit from the phenothiazines. Some show no improvement, and others show varying degrees of improvement while on such medication. However, *on the average,* the phenothiazines reduce psychotic symptoms in groups of schizophrenics.

Major advantages of chemotherapy are that it has reduced the need for lengthy hospital stays for psychotics, and reduced stress in neurotic and normal individuals. In short, these drug therapies often make a great difference in an individual's ability to cope with life, and they have all but eliminated the need for institutional confinement, straitjackets, and the like. But there is a price to pay. Side effects, sometimes life-threatening, often plague those on chemotherapy programs. In addition, psychological and possible physiological addiction is a risk, particularly when medication schedules are not strictly adhered to and monitored.

Chemotherapy only controls symptoms, it is not a cure for behavioral disorders. The specific action of therapeutic drugs on the nervous system is not well understood for the most part, although it seems clear that most of these agents affect neurotransmitter substances. Until a better understanding of the biochemical correlates of various behavioral disorders is achieved, coupled with a knowledge of specific drug effects on the nervous system, chemotherapy will continue to be a stopgap rather than a curative measure.

This patient is about to receive electroshock therapy, a controversial procedure for treating severe depression.

Electroshock Therapy

Electroshock therapy (EST), also called electroconvulsive therapy (ECT), was introduced in the 1930s as a treatment for schizophrenia, but is now used almost exclusively in the treatment of severe cases of depression. EST involves the delivery of electrical current directly through the brain via electrodes placed on each side of the head. A voltage usually ranging from 70 to 150 volts AC, applied for a fraction of a second, produces a convulsive seizure similar to a grand mal epileptic seizure that lasts for about a minute. Apparently there is no pain associated with this treatment, and patients are given a mild sedative and muscle relaxant so that they are asleep before the treatment begins. This prevents bodily injury that could occur as a result of the seizure.

EST appears to be a quick and effective means of snapping many patients out of a severe depression, even more effective than the antidepressant drugs we have described (Avery & Winokur, 1977). Nevertheless, EST does not prevent relapses, and it represents a very drastic therapeutic procedure, given the potential for producing damage to the nervous system through convulsions. Also, some patients receiving EST claim that they have suffered memory losses following treatment. Therefore, it is used only as a last resort and with a great deal of caution.

We do not know how EST works to produce its therapeutic effects, even though the procedure has been in use for fifty years. One possibility is that it destroys short-term memories, including the feelings of guilt, despair, and loss of control that accompany depression. Consistent with this hypothesis is the observation that electroconvulsive shock delivered to rats often impairs more recent memories while leaving long-term memories intact (McGaugh & Herz, 1972). Another possibility is that EST affects neurotransmitter action in the nervous system. Both of these explanations are highly speculative, however; further research will have to be done before EST effects are understood.

Psychosurgery

The most widely known psychosurgical technique is the **prefrontal lobotomy,** introduced in the 1930s. This technique involves severing the fibers connecting the frontal lobes of the cerebrum with the thalamus. The technique was found to be somewhat effective in calming severely agitated psychotic patients when no other means seemed to work. However, there were reports of side effects that sometimes rendered the individual a "vegetable," and were often considered worse than the original symptoms (Valenstein, 1982).

Psychosurgical techniques have been refined a great deal, and it is now possible to destroy only very small areas in the brain through the use of microelectrodes (Valenstein, 1973). However, psychosurgery of any kind is the most drastic of all biological therapies we have considered, because it is irreversible; nerve fibers in the central nervous system do not regenerate. Therefore it is used rarely and only as a last resort.

Psychoanalytic Therapy

Psychoanalysis was the first "talk therapy" designed to get a person to reexperience repressed childhood conflicts and thereby reduce anxiety. The major assumption behind psychoanalysis is that achieving insight into unconscious conflicts can lead to a cure for behavioral disorders. Sigmund Freud pioneered psychoanalysis, which, in its classical form, consists of four basic methods: free association, dream interpretation, analysis of resistance, and analysis of transference.

In **free association** the patient says whatever comes to mind, no matter how seemingly bizarre or illogical. Freud believed that what patients say, no matter how random-appearing, is determined by unconscious motivating forces. The words they use, or avoid, may reveal to the psychoanalyst underlying themes of sexual conflict, hostility, guilt, or anxiety. What the patient says provides areas for further exploration. For example, an adult male patient may describe thoughts of his father that are filled with hostility and fear, while describing his mother in glowing terms. Given psychoanalytic theory's emphasis on the Oedipal conflict as a major source of neurotic disorders, the analyst may well consider these thoughts significant, and attempt to get the patient to talk more about them. Ultimately the analyst hopes the patient will remember key events associated with his father that have been repressed, events that may be responsible for his feelings of hostility and for the neurosis in general.

Freud placed a great deal of stock in **dream interpretation** as a key to unlocking the mysteries of the unconscious mind. His book *The Interpretation of Dreams* (1900) is a detailed account of dream interpretation and its role in therapy. In fact, it is a very readable and delightful introduction to psychoanalysis. Freud believed that dreams contain material normally unavailable to the waking memory and thus provide a wealth of important material for analysis. While a person is awake the ego prevents unacceptable impulses and conflicts from entering into conscious awareness through its various defense mechanisms, especially repression. But during sleep, repressive forces are lowered and thus information otherwise unavailable to the conscious aspect of personality surfaces in dreams.

Freud saw dreams as consisting of a manifest content and a latent content. The *manifest content* is how the dream appears to the dreamer: the events, characters, places, and so on, that are remembered. The *latent content* is the underlying meaning of the dream. Dreams are supposed to symbolize (and therefore disguise) the unconscious motives and conflicts of the dreamer. The objective of the analyst is to help the patient become aware of the latent content of his or her dreams, and identify the sources of that content.

Analysis of resistance refers to attempts by the analyst to probe the patient's efforts to block or resist analysis. Blocking may occur during free association, when the patient refuses to continue a particular line of conversation, minimizes its importance, or changes topics. It may also occur in response to the analyst's suggestion that a particular unconscious motive is responsible for a dream the patient has had. Resistance can be much more subtle, as when the patient begins coming late for appointments or forgets to show up for his or her therapy session.

Freud believed that people resist when they are close to uncovering repressed material that is causing them anxiety; they simply do not want to go through the agony of dealing with unacceptable impulses or unpleasant memories hidden from conscious awareness since early childhood. The analyst attempts to break down the resistances of the patient in an effort to help the patient develop insight.

The final psychoanalytic method we shall discuss is *analysis of transference.* It is common in therapeutic encounters for the patient to develop deep positive or negative feelings toward the therapist.

Freud called this phenomenon **transference.** Similar feelings on the part of the therapist for the patient can also occur. This is called **countertransference.** Freud believed that transference could be explained as the displacement of the patient's love, hate, or both for his or her parents onto the analyst. In other words, through the course of therapy the analyst became a father- or mother-figure for the patient. Of course the patient does not realize this at first, and may be convinced that the strong emotions are specific to the therapist. The analyst attempts to use the phenomenon of transference as a vehicle for helping the patient. Transference allows the patient to reexperience infantile emotions and conflicts in a safe, warm, and nonhostile atmosphere.

It is difficult to evaluate the effectiveness of psychoanalysis. Most psychoanalysts see no need to provide experimental or other scientific evaluations of their therapeutic procedures. From the psychoanalyst's perspective, "scientific" support is gained from case histories that show improvement of the patient. Of course, improvement is defined by the analyst or by the patient, and may or may not be recognized as such by others who observe the patient. Of the few systematic outcome studies which have attempted to evaluate the effectiveness of psychoanalysis, none reveal a major therapeutic advantage for psychoanalysis over other forms of therapy (Prochaska, 1979).

Case, history and anecdotal evidence suggest that psychoanalysis is not effective in treating psychotic disorders, which Freud himself acknowledged. It is most easily applied with neurotic individuals, especially those who are highly verbal.

Learning Therapies

Therapies that have developed from stimulus-response models of learning, especially the models of classical conditioning and instrumental learning, are often referred to as **behavior therapy** because the therapeutic effort is directed toward changing behavior rather than inferred mental states or conditions. However, the term *behavior therapy* may be confusing or misleading for a number of reasons. First, it is not an accurate identifying label, because *all* therapeutic approaches are concerned with some aspects of behavior. Second, it does not capture the essence of learning therapies—that they are based upon principles of *learning.* Finally, many so-called behavior therapies have come to incorporate a *cognitive* focus as well as a focus on overt behavior, which broadens their scope considerably and, some would argue, improves their effectiveness.

The learning therapies are based upon well-researched laboratory principles of learning and cognition. The assumption is that abnormal behaviors are *learned* and maintained according to these principles, just like other behaviors. Therefore, they should be subject to extinction and replaceable with appropriate behaviors according to the same principles. Learning therapies also emphasize *present* influences responsible for maintaining abnormal behavior; they typically do not seek to reconstruct the distant past in a search for the root causes of a behavioral disorder. Finally, because learning therapies arose from experimental psychology, there is a concern for *objective evaluation* of the effects of therapy, a concern not always shared by psychoanalytic or certain other "talk therapies."

Snake phobias are often treated using learning therapies, particularly those based upon principles of classical conditioning.

Classical Conditioning Therapies

There are three major kinds of therapies based upon Pavlov's classical conditioning principles. These are *flooding,* a type of extinction; *desensitization,* a type of counterconditioning; and *aversive conditioning,* another type of counterconditioning. The first two procedures are generally used to eradicate irrational fears or aversions, such as those seen in phobias. The third procedure, aversive conditioning, attempts to *establish* an aversion for a particular stimulus, such as conditioning an alcoholic to experience intense nausea in response to smelling or tasting an alcoholic beverage.

In **flooding,** the therapist presents the stimulus or stimuli the patient fears most. The goal is to elicit an intense anxiety reaction, either directly or by instructing the person to imagine the feared stimulus, and to keep the person in contact with the feared stimulus until the anxiety begins to subside. For example, if a person has a phobic fear of flying in airplanes, treatment might involve having the individual fly from Los Angeles to San Francisco and back repeatedly and experience the phobia in the presence of the therapist. It is a simple matter of extinction, presenting the conditioned fear stimulus and eliciting the conditioned fear response. However, the phobic person ideally never encounters an *unconditioned* fear stimulus, such as an actual life-threatening situation. As extinction trials proceed, the conditioned fear should decline, just as conditioned responses in the laboratory decline when the conditioned stimulus is presented repeatedly but is never followed by the unconditioned stimulus. Put in more cognitive terms, the person may begin to realize the phobia is unjustified.

Theoretically, for flooding to be effective it is important that the individual remain in contact with the feared stimulus. If a phobic person reduces anxiety by avoiding the feared stimulus, the phobia may well remain intact or even be strengthened. For example, for someone terrified of enclosed places, getting off an elevator at the second floor instead of riding it to the twentieth and back prevents the fear from being experienced continuously and thus disrupts the extinction process.

Like flooding, **desensitization** is a therapeutic technique that involves extinction. The person is confronted repeatedly with a feared stimulus, but in addition to extinction there is an attempt to *countercondition* a response that will be *incompatible* with the conditioned fear. Usually the response to be counterconditioned in cases of phobias or other anxieties is that of deep muscle relaxation. The basic idea is that one cannot be both anxious and relaxed at the same time. Muscle relaxation can be induced via direct instruction or through the use of imagery and hypnosis.

A widely used version of desensitization is called **systematic desensitization,** pioneered by Joseph Wolpe during the 1950s. In systematic desensitization the feared stimulus is only introduced *gradually,* unlike ordinary desensitization or flooding. The patient constructs a list of stimuli that range from lowest to highest in terms of how much anxiety they produce. For example, if you were deathly afraid of flying in airplanes, you might be most fearful of actually looking out the window of an airliner cruising at forty thousand feet. It might be only slightly less frightening for you to be in an airplane that is taxiing down the runway in preparation for takeoff, and even less frightening to be taxiing following a safe landing. At the very bottom of your list might be the experience of hearing the words *airplane, DC-l0, 747,* and so on, which may elicit little if any anxiety. Once the list is completed the therapist would present you with, or have you imagine, a stimulus at the bottom of the list. This would be done while you were deeply relaxed. Gradually, more fearful stimuli would be presented. The therapist would not progress to an item higher on your scale of fear until you could maintain a state of relaxation with a given stimulus. The ultimate goal would be to have you ride in an airplane, unafraid, while looking out the window at forty thousand feet.

Both flooding and desensitization have proved to be markedly successful in treating phobias and other specific anxieties. For example, one well-controlled study compared systematic desensitization with three other approaches: insight therapy, attention coupled with a placebo "tranquilizer," and no therapy at all (Paul, 1966, 1967). The dependent variable in this study was fear of public speaking in college students. Results indicated that, depending on the particular measure of anxiety used, between 87 and 100 percent of the subjects receiving desensitization showed significant improvement, 53 to 60 percent receiving insight therapy improved, 47 to 73 percent receiving the attention-placebo combination improved, and 7 to 28 percent of those receiving no therapy showed improvement. The general pattern of these results was maintained over a two-year period. The effectiveness of desensitization and flooding has been confirmed in clinical case studies. There is reason to believe that flooding may provide a more rapid means of reducing fear than desensitization, although perhaps it is not as comfortable for the patient.

It is not entirely clear that the effectiveness of flooding and desensitization is due to extinction of abnormal patterns of behavior, or to counterconditioning of appropriate emotional responses. It is possible that both flooding and desensitization allow for a simpler form of learning—*habituation* of fear to repeated presentations of feared stimuli. It is also likely that there are important *cognitive* factors involved, such as concluding that a fear of airplanes, snakes, elevators, or what have you is illogical and unwarranted.

The third and final type of classical conditioning therapy we will mention is **aversive conditioning.** The idea here is to *condition* a fear or aversion rather than to reduce one. Why would anyone want to do something like this? Cases involving addiction to alcohol or other drugs, excessive eating or smoking, or deviant and compulsive sexual preferences and practices all require the breaking of an attachment to or dependence upon a particular stimulus. Aversive conditioning seeks to countercondition an aversion for the object of attachment or dependence in order to eliminate the individual's preoccupation with that object.

Aversive conditioning has been used in certain alcohol and drug abuse programs, weight-loss clinics, and smoking reduction programs, and in attempts to reorient individuals' sexual preferences. The techniques all involve pairing an aversive stimulus, such as a moderately painful electric shock, with the stimulus the person is attached to (for example, food, cigarettes, or alcohol). One technique that has been devised for use with alcoholics has the patient visually image a scene in which alcohol is associated with some very unpleasant happenings. Cautela (1966), who developed this kind of aversive conditioning, called *covert sensitization,* describes some of the things the therapist attempts to get the patient to image:

> You are walking into a bar. You decide to have a glass of beer. You are now walking toward the bar. As you are approaching the bar you have a funny feeling in the pit of your stomach. Your stomach feels all queasy and nauseous. Some liquid comes up your throat and it is very sour. You try to swallow it back down, but as you do this, food particles start coming up your throat to your mouth. You are now reaching the bar and you order a beer. As the bartender is pouring the beer, puke comes up into your mouth. . . . You have to open your mouth and you puke. It goes all over your hand, all over the glass and the beer. You can see it floating around in the beer. Snots and mucus come out of your nose. Your shirt and pants are full of vomit. The bartender has some on his shirt. You notice people looking at you. You get sick again and you vomit some more and more. You turn away from the beer and immediately you start to feel better. As you run out of the bar room, you start to feel better and better. When you get out into clean fresh air you feel wonderful. You go home and clean yourself up (p. 37).

In the main, aversive classical conditioning has had mixed success as a therapeutic technique. Covert sensitization seems to be quite effective in changing various deviant patterns of sexual activity, such as pedophilia (in which children are the preferred sexual objects), exhibitionism, and sadistic fantasies. On the other hand, its success is not nearly as well established in treating alcoholism or excessive smoking or eating (Martin, 1981).

There are at least three major difficulties involved in using aversive conditioning techniques. One involves the choice of an effective aversive stimulus. We saw in Chapter 7, for example, that it is very easy for rats and humans to learn aversions to tastes or smells if such stimuli have been paired with digestive upset, but not if they have been paired with electric shock. It is as if certain species are genetically predisposed to make some associations over others because such selectivity has survival value for the animal in its environment. Based upon this research, we might expect that electric shocks paired with the smell and taste of beer, wine, or liquor would be less likely to produce an aversion to alcohol than would induced nausea and vomiting (Garcia, Hankins, & Rusiniak, 1974). In fact, the evidence to date is consistent with this expectation. In a review of studies of aversive conditioning and its effects on alcoholism, G. T. Wilson (1978) concluded that electrical aversive conditioning was ineffective. Peter Nathan and Thomas Lipscomb

(1979), researchers at the Alcohol Behavior Research Laboratory of Rutgers University, have these comments:

> It is ironic that the behavior change procedure linked most closely with both behavior therapy and alcoholism—electrical aversion—has now proven itself, in the eyes of many, to be ineffective. . . .
>
> Perhaps the most convincing demonstration of the ineffectiveness of electrical aversion as a treatment for alcoholism was that by Wilson, Leaf, and Nathan (1975) who directly tested the widespread presumption that electrical aversion conditioning establishes conditioned aversion to ethanol. After receiving a very large number of aversion conditioning trials extending over several days, alcoholics were permitted to drink *ad libitum* [freely] in a laboratory setting which neither encouraged nor discouraged that consumption. Results were that subjects drank with undiminished enthusiasm, just as they had during a comparable *ad libitum* period pretreatment; Wilson and his coworkers concluded that conditioned aversion had not been established by the aversion conditioning procedure.
>
> We conclude, then, that electrical aversion conditioning almost certainly does not induce conditioned aversion to ethanol and, for that reason, that it does not merit further consideration as a treatment for alcoholism (p. 320, 322).

In contrast to electrical shock, drug-induced nausea and vomiting following consumption of alcohol has been shown to be an effective treatment for some inpatient alcoholics (Nathan & Lipscomb, 1979). One difficulty with even chemically induced aversions, however, is that their effectiveness does not always generalize well outside the clinic. In other words, the aversion to alcohol, once established, often is not maintained without further periodic conditioning. This is not always easy to effect, since the alcoholic must be highly motivated to self-administer the nausea-producing agent, or to return to the treatment center for such therapy. Often, such expectations appear to be unrealistic.

Another difficulty with aversive conditioning, as with any kind of punishment technique, is that at best it produces a reluctance to engage in a particular kind of behavior, but does not provide an *alternative mode of action* to replace the unwanted behavior.

Finally, some would question the ethics of using aversive techniques, regardless of their effectiveness, because they induce a certain amount of pain and suffering in the individual.

Instrumental Learning Therapies

Therapies based upon principles of instrumental learning (see Chapter 8) all employ the concept of **contingency management.** Abnormal behavior is assumed to be learned because of the events that are (or were) contingent upon the behavior. A child may learn to be overly aggressive because in the past this has led to getting his own way and has brought with it a great deal of attention. In this instance, getting one's way and getting attention are *contingent* upon behaving aggressively. Because these contingent events increased the behavior that brought them about, they are considered to be positive reinforcers.

Therapy that is based upon instrumental learning principles would involve managing the contingencies in order to reduce aggression. For example, the therapist might try to remove the positive reinforcer by instructing family members in the art of not giving in to the child's aggressive episodes, or perhaps ignoring them. Attention would be given, however, when the boy is not behaving aggressively. Thus the contingency is changed; behaving aggressively will no longer lead to benefits for the boy, but behaving nonaggressively will. Aggressive outbursts, temper tantrums, and the like will be placed on extinction, since the positive reinforcers are given only for nonaggressive interactions. Theoretically, aggressive outbursts should decline in frequency if the contingency management program is adhered to faithfully.

In instrumental learning therapies there is great emphasis on *identifying* and *tracking* target behaviors that are to be modified, and determining as precisely as possible which environmental contingencies are responsible for maintaining deviant behaviors. This makes it possible to know which contingencies need managing, and whether such management is working to change the problem behaviors.

In a token economy, tokens are given to patients as reinforcers for appropriate behavior. Later, these tokens can be exchanged for a variety of more tangible rewards.

Positive Reinforcement and Extinction Most contingency management therapies emphasize the combination of positive reinforcement and extinction. Such therapies have been used to treat a wide variety of behavior disorders and to teach appropriate social, learning, and self-help skills. Basically, they consist of providing reliable positive reinforcement for appropriate behaviors, and no reinforcement (extinction) for inappropriate behaviors, as in the case of aggressiveness just described.

A formalized version of this kind of therapy is the **token economy,** used widely in treatment programs carried out in institutional settings. A successful token economy specifies which behaviors are appropriate and which inappropriate, the conditions under which behaviors will be reinforced, and the precise nature of the reinforcers. Appropriate behavior is reinforced with tokens, poker chips, stars on a chart, or any other agreed-upon signifiers. The key to the token economy is that the tokens can be exchanged later for a variety of more concrete rewards, such as candy, a trip to the zoo, movies, books, a visit home, a private room, or other reinforcers that the patient and therapist agree upon. Inappropriate behaviors, or the failure to engage in designated behaviors, merit no tokens and therefore no rewards. A major advantage of the token economy is that patients do not lose interest in the positive reinforcer, since it can be exchanged for a variety of things which they desire. Token economies have proved effective in managing various behaviors in clinical and educational settings.

Punishment Therapies involving punishment are rarely used and usually only when other techniques have failed and there is scientific justification for thinking that punishment might work. Punishment in the form of electric shock (*not* electroconvulsive shock), usually delivered to the feet or arms, seems to be effective in reducing self-injurious behaviors often seen in retarded or psychotic institutionalized children (Lovaas, Schaeffer, & Simmons, 1965).

Although punishment may seem distasteful, it is sometimes the only apparent way to reach severely disturbed children who are bent on self-destructive behavior. Without the use of punishment, such children might inflict serious damage on themselves, and therefore would have to be kept in restraints. However, even though punishment might be effective in certain cases, its use should be influenced by several considerations. Schreibman and Koegel (1981) elaborate:

> First is the nature of the response suppression desired. Punishment is often the treatment of choice when it is deemed undesirable to allow the behavior to continue any longer. . . . Second is the fact that punishment may be used when other procedures such as extinction or rewarding incompatible behaviors have failed. Third is the fact that some therapists are more comfortable with one approach than another. If the therapist is not comfortable with punishment or with the particular punishing stimulus being used, he probably will not be consistent with the procedure. This would, of course, render the procedure ineffective. Fourth, one would typically opt for the mildest punishment that will prove effective for a particular disorder (pp. 519–520).

Trends in Instrumental Learning Therapies Instrumental learning therapies have proved especially effective in treating conduct disorders in school children; reducing self-stimulating and self-injurious behaviors in psychotic and retarded children; teaching rudimentary language skills to mute psychotic children; training appropriate toileting and other self-help skills in nonretarded children and severely retarded children and adults; improving attentional and academic skills in emotionally disturbed, learning-disabled, and mildly retarded children; and managing the social behavior of various groups of institutionalized children and adults.

Recent trends in instrumental learning therapies include a greater effort at programming generalization into treatment programs and greater emphasis on cognitive and personal factors in treatment. The first trend, programming *generalization,* seems to be in response to criticisms that learning therapies usually produced treatment gains that were specific to the therapeutic environment and were short-lived. However, to expect that a behavior change will automatically generalize from the clinic to the home or school, or will be permanent, was perhaps naive in the first place. At any rate, more attention is now being given to teaching *rules* and *strategies* designed to govern behavior in a *variety* of settings (Wetherby & Baumeister, 1981; Wilson & O'Leary, 1980).

The second trend, greater consideration of *cognitive* and *personal* factors, appears to reflect the greater cognitive emphasis in experimental psychology, and an increasing recognition that the person as a whole, rather than a specific behavior, is the proper object of treatment. Thus we see more emphasis on reinforcing or extinguishing certain cognitions in the hope that cognitive change will lead to behavioral change. We also see more attempts to bring behavior under *self-control* rather than leaving it under the control of external environmental contingencies (Wilson & O'Leary, 1980).

An autistic child is acquiring a sign vocabulary through observational learning.

Observational Learning Therapies

We saw in Chapter 8 that observational learning — learning through imitation — can provide a very rapid means of behavior change without reinforcement. This makes it a potentially useful therapeutic technique, and in fact "modeling" therapies have proved effective in reducing phobias and other anxieties in children. The technique is simply to have the patient observe models who do *not* become overly anxious, depressed, withdrawn, and so on in stressful situations. A major advantage of this kind of learning therapy is that the patient does not have to experience the source of anxiety directly. Rather, the *model* is observed confronting a threatening stimulus, being rewarded for appropriate behaviors, or not rewarded for inappropriate behaviors. Thus patients modify their behaviors, including cognitions, in accord with those of the model.

It is difficult to imagine that observational learning is not at the heart of many therapies — learning, psychoanalytic, or whatever. This seems especially clear in certain substance-abuse therapeutic groups such as Alcoholics Anonymous, in which members serve as examples (models) of successful attempts at gaining freedom from dependency, in addition to offering cognitive help. It is also the case that a therapist in either an individual or group situation serves as a model for appropriate behavior.

Cognitive Restructuring in Learning Therapies

We have already indicated that there is a strong trend in learning therapies to go beyond overt behavior and include cognition as a legitimate focus. Examples include the use of imagery in classical conditioning therapies such as desensitization; the reinforcement of thinking patterns that can mediate behavior in instrumental learning therapies; and modeling therapy, which is based upon observational learning, a type of learning that involves cognitive processes. But in addition there are therapies incorporated within a learning framework that attempt to restructure cognitions directly, rather than focus upon overt behavior. A widely cited example of this kind of treatment is rational emotive therapy, developed by Albert Ellis.

Rational emotive therapy is based upon the premise that it is a person's belief system that is largely responsible for abnormal behavior. The idea is that extreme anxiety, for example, is not conditioned directly from encounters with the external environment but from an individual's *irrational interpretations* or cognitions of these events. Ellis (1962) explains that

> human beings are the kind of animals that, when reared in any society similar to our own, tend to believe several major fallacious ideas; to keep reindoctrinating themselves with these ideas in an unreflective, autosuggestive manner; and consequently to keep actualizing them

> in overt behavior that is self-defeating or neurotic. Most of these irrational ideas are, as the psychoanalysts have pointed out for several decades, instilled by the individual's parents during his early childhood and are tenaciously clung to because of his attachment to his parents and because the ideas were ingrained, imprinted, or conditioned before later and more rational modes of thinking were given a good chance to gain a foothold (p. 59).

If abnormal behavior results primarily from learned irrational beliefs, then it would follow that therapy should focus on changing these patterns of thinking, as Ellis indicates:

> It is the task of the psychotherapist to work with individuals who are needlessly unhappy and troubled, or who are weighted down with intense anxiety or hostility, and to show them (a) that their difficulties largely result from distorted perception and illogical thinking, and (b) that there is a relatively simple, though work-requiring, method of reordering their perceptions and reorganizing their thinking so as to remove the basic cause of their difficulties (p. 36).

According to Ellis and others, neurotic individuals often repeat to themselves ("self-verbalize") their irrational propositions, thus strengthening them and making it difficult to adopt a more logical analysis. For example, a seriously depressed woman may continue to think to herself that she is no good to anybody, doesn't deserve to have a good time, must pay for her sins, and is constantly being evaluated negatively by others. Such thoughts and statements from depressed persons are common, but typically do not square with the facts. They are usually either tremendous exaggerations or else outright untruths. One way to treat such disordered thought would be to get the patient to see why they are irrational, and to substitute a more rational interpretation directly.

> I . . . often say to my patients: "Look: you insist that you are worthless, valueless, and no damn good. Now give me some evidence to prove your hypothesis." Of course, they can't. They almost immediately come up with some statement as: "Well, I am worthless because I'm no good at anything," or "I have no value because no one could possibly care for me." . . . "Incompetence, unlovability, or what you will," I tell them, "only make you valueless because you *think* they do. Others who think differently can and do consider themselves worthwhile even though they may be ten times more incompetent or unlovable than you."
>
> I then go through a whole battery of reasons with these patients which indicate why it is untenable for them to consider themselves worthless. . . .
>
> "Let us face it," I tell them. "Assuming that you do measure your intrinsic and extrinsic value by the same kind of scales, and therefore arrive at the conclusion that you are worthless, you must, once this conclusion is reached, thereafter be prey to everlasting feelings of anxiety, guilt, depression, and other kinds of emotional upset. On the other hand, if you do *not* conclude that you are worthless . . . you may live with a minimum of anxiety and hostility. Obviously, then, the only sane pragmatic course to follow is to assume that you are *not* valueless" (Ellis, 1962, pp. 154–55).

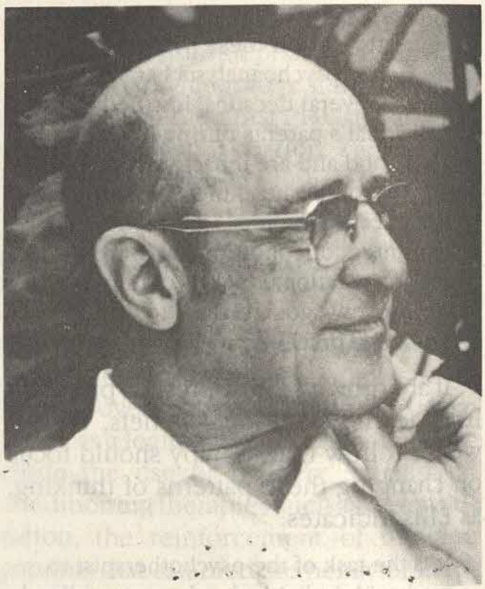
Additional procedures, more in line with conditioning and learning techniques, would be to teach or model logical and positive self-verbalizations, have the patient practice these, positively reinforce them, and extinguish irrational self-verbalizations.

Humanistic-Existential Therapies

We now turn to a loosely knit group of therapies that differ substantially from both learning and psychoanalytic therapies. The humanistic-existential therapies are much less formal than other psychological therapies, and are based more upon philosophical considerations than scientific ones. These therapies are more concerned with changes in *feelings* than with cognitive or behavioral changes. And compared to learning and psychoanalytic approaches, humanistic-existential therapies attribute a greater degree of freedom of choice and responsibility to people, attribute less importance to past events in determining abnormal behavior, and encourage a greater degree of understanding by the therapist of the subjective world of the patient. In spite of these shared characteristics, there is probably more variation within this group of therapies than within either the psychoanalytic or the learning therapies.

Client-Centered Therapy

Carl Rogers developed client-centered therapy, the most popular humanistic therapy. The therapy is based on the notion that abnormal behavior results when a presumed innate drive to *self-actualize* is thwarted. According to Rogers, as well as other humanistic personality theorists such as Maslow and Goldstein, people have an innate tendency to actualize their potential for self-growth and understanding. But Rogers says they also have a powerful need for *unconditional positive regard,* a need which is manifested in early childhood. If children perceive that they are loved unconditionally, this will result in a positive self-image and allow the true self to emerge and develop normally. On the other hand, if children perceive that parental love is forthcoming *only* if they behave in an acceptable fashion, then they will feel anxious and seek all the more to win unconditional regard from their parents. The result is a conditional self-acceptance in which people value themselves *only* when doing something that is valued by their parents. Such people are in conflict with respect to self-acceptance, and this conflict impedes natural self-growth and actualization.


Carl Rogers is best known for developing client-centered therapy.

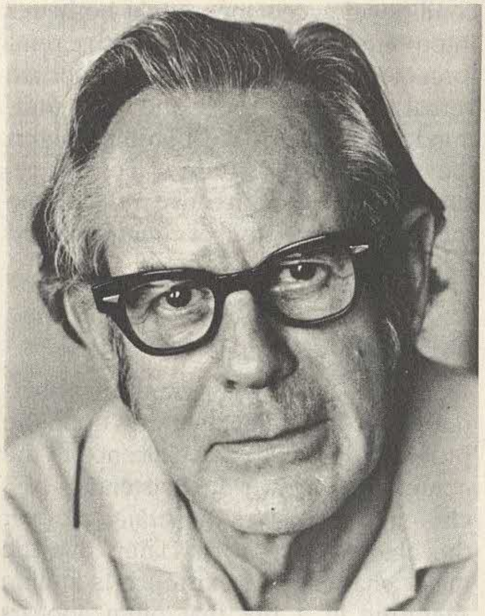
The key to client-centered therapy is for the therapist to provide the client (Rogers preferred the term *client* over *patient*) with unconditional positive regard. That is, the client is totally approved of as a person, regardless of his or her actions. The goal of the therapist is to experience things the way the client does—to empathize with the client—and to provide a warm and nonthreatening atmosphere in which the client can express innermost feelings and thoughts freely. It is very important to this kind of therapy that the therapist relate with the client in a genuine, person-oriented fashion, not as the "doctor" in an authoritarian relationship. It is also important that the therapist be as *nondirective* as possible, serving simply to reflect back and clarify things expressed by the client, rather than giving advice, analyzing a dream, or systematically reinforcing a particular behavior. The idea is that the client will get in touch with his or her true feelings, and will come to develop a degree of self-acceptance because of the acceptance shown by the therapist. Presumably this will lead to self-awareness and an integration of the formerly disunified self. The client will then be able to make choices in life without the threat of disapproval from self or others, and will experience a more fulfilling and happier life.

Unlike most other personality theorists—humanistic, existential, or psychoanalytic—Rogers has been a leader in scientifically evaluating the effectiveness of his client-centered therapy. Although results of his and others' evaluations have not always confirmed the adequacy of certain Rogerian concepts, nor proved that client-centered therapy is the "best" therapy, they have been insightful and have led to many changes and refinements in the therapeutic enterprise. For example, some years ago one of Rogers's colleagues found that instances of *unconditional* positive regard by the therapist were difficult to find in the tapes of Rogers's own therapeutic sessions (Truax, 1966). Rather, most of the "positive regard" was found to be closely associated with particular types of statements made by the client. What Rogers thought to be unconditional acceptance might be better interpreted as *conditional* positive reinforcement for the client's appropriate verbal responses. These and other findings led Rogers to place less emphasis on the unconditional nature of positive regard and the nondirective role of the therapist in his system of client-centered therapy.

Existential Therapy

Existential therapy is rooted in existential philosophy, which centers upon the problems of day-to-day existence in the contemporary world. Existential psychology emphasizes the *subjective* over the objective world. It claims that the major challenge of existence is finding *meaning* in a life that often appears meaningless and hopeless, and ascertains that man's increasing reliance on science and technology has led to a weakening of value systems and the family, accompanied by depersonalization and a sense of hopelessness. Abnormal behavior results when the individual cannot discover meaning in life, and succumbs to the dehumanizing forces in society. Existential therapy focuses on helping people understand the "human condition," realize that they are *free* to make choices that can change behavior, and adhere to a value system that can guide these choices.

Major proponents of existential therapy include the Austrian psychiatrist Victor Frankl and the American psychologist Rollo May. For the most part the existentialists do not emphasize a particular set of procedures, and do not feel compelled to analyze their therapy scientifically. Objective analysis would go contrary to the philosophical beliefs of the existentialists. Also, it would reveal nothing about the subjective world of the



Rollo May is a well-known existential psychologist.

therapeutic encounter, which they see as the proper focus of therapy. Rather, their emphasis is on the "genuine" subjective experience of the patient and therapist in interaction.

> Existential therapists do not follow any rigidly prescribed procedures, but emphasize the uniqueness of the individual and his "way-of-being-in-the-world." They stress the importance of *confrontation*—challenging the individual directly with questions concerning the meaning and purpose of his existence—and the *encounter*—the complex relationship that is established between two interacting human beings in the therapeutic situation. In contrast to behavior therapy, existential therapy calls for the therapist to share himself—his feelings, his values, and his existence—and not to let the client respond to him as anything other than he really is . . . (Coleman, 1976, p. 693).

Psychological Therapies in Perspective

We have surveyed the major types of therapy for behavioral disorders. There are many more, which for the most part are refinements of the psychoanalytic and humanistic-existential approaches. And, as you may be aware, there has been a proliferation of so-called pop therapies over the past fifteen or so years. These include "primal scream," "encounter," "rebirthing," and "est" (Erhard Seminars Training) therapy, none of which has much basis in scientific theory or fact.

Why are there so many different kinds of therapy? We have already noted that there are at least as many different therapeutic approaches as there are theories of personality and abnormal behavior. As long as psychologists have different ideas about the causes of behavioral disorders, there will be different remedies prescribed. (See Table 22.2 for factors that may influence the outcome of therapy.) Of course the desire for power, publicity, and wealth will continue to encourage certain individuals to market new forms of therapy. The rationale for many pop therapies usually has less to do with scientific theory than with crowd-drawing entertainment potential.

But don't some therapies, once tried, turn out to be more effective than others? And if so, how can the others compete once the facts pertaining to effectiveness are known? These are very reasonable questions, but the answer to the first one is far from clear, making the second irrelevant. There are many problems that plague researchers who attempt to compare the effectiveness of different therapies. For example, what should constitute the criteria for evaluating ef-

TABLE 22.2 Factors That May Influence the Outcome of Any Given Therapy

The disorder	History of the disorder Severity of symptoms History of onset Suspected causes
The client	Motivation to change Values Social support from family, friends Intelligence Education Socioeconomic status Financial stability Sex Race
The therapist	Personality characteristics Values Theoretical perspective Intelligence Experience Training Sex Race

fectiveness? In other words, how will researchers define therapeutic change *operationally?* Should they depend on what the therapist says about the patient, on what the patient says, or on overt behavior? How long must the improvement be maintained, and should it show generalization across different environments? Must there be a total change in basic personality structure, or is change in a single aspect of personality sufficient to be classified as improvement?

Compounding the difficulty involved in devising an index of therapeutic change is the fact that therapists of differing orientations usually will argue about the validity of whatever index is proposed. A psychoanalyst considers the patient's development of *insight* into the childhood origins of pathology an appropriate index of therapeutic improvement. But an existential therapist may not be satisfied unless the patient begins to accept *responsibility* for pathology. A learning therapist may consider self-reports of new "insights" or a new "sense of responsibility" meaningless unless they are accompanied by an *objectively measurable* improvement in *overt behavior.* Thus attempts to evaluate the effectiveness of different therapies are bound to offend one therapeutic camp or another if any *single* criterion of therapeutic effectiveness is used.

Another difficulty in conducting research on therapeutic effectiveness, one that has been overcome only rarely, involves executing the proper design of the research study. It may seem like a simple matter of comparing groups of patients undergoing different kinds of therapy, and documenting which therapy produces the best results. But such a straightforward comparison will leave many questions unanswered. Suppose we find that one kind of therapy is significantly superior to another. This does not tell us whether *any* of the therapies are more effective than no treatment at all. We would need a control group of individuals suffering from the same problems, but receiving no formal therapy, in order to answer this question. And the selection of the no-treatment control group is very important. Suppose we use people who are not seeking some kind of therapy, and then find that they show less improvement than individuals in the therapeutic groups. Can we conclude that at least some kind of therapy is better than no therapy at all? The answer is no, because it could be that the no-treatment control subjects are *less motivated* to get better than those who have sought therapy. One way to try to control for such motivational variables is to form the no-treatment group from individuals who are on a mental health clinic waiting list.

Since these people are actively seeking therapy, they should be as motivated to get better as those actually in treatment.

Even though there are many problems involved in evaluating therapeutic effectiveness, there are some general conclusions that can be made based on the evidence to date. First, in spite of some early claims that, on the average, psychological therapies are no more effective than no treatment at all (Eysenck, 1961), more recent evaluations show this pessimistic appraisal to be unwarranted. At least with groups of neurotic individuals, psychotherapy is associated with an improvement rate of about 60 percent, while the rate of spontaneous improvement (no formal therapy) is about 40 percent (Bergin, 1971). These statistics are averages that can mask what is happening in individual cases. In fact, it appears that some *individual* patients improve markedly with therapy, others show little if any improvement, and a small percentage (5 to 10 percent) actually get worse (Bergin & Lambert, 1978). This latter finding is particularly disturbing, and may be related to therapist incompetence, although this has not been established clearly. Until the reasons for this so-called *deterioration effect* are known, it is perhaps wise to follow Martin's advice: "*Caveat emptor*—let the buyer beware" (Martin, 1981, p. 180).

In spite of the difficulties in comparing the effectiveness of different therapies, are there at least hints as to which ones are better than others? There are hints, but they need a great deal of qualification. Compared to psychoanalytic and humanistic-existential therapies, learning therapies show more "demonstrated" successes, especially with phobias and other anxieties. Perhaps this is simply because learning therapists have invested more effort in evaluating their approach than have other therapists. The few well-designed comparisons of the different psychological therapies actually have revealed little difference in overall effectiveness. However, there is some evidence that the effectiveness of certain therapies depends upon the characteristics of the patient. For example, Sloane, Staples, Cristol, Yorkston, and Whipple (1975) found that insight-oriented therapies were only effective with relatively young, educated, and financially stable patients. Learning therapies were effective with a broader range of patients, and seemed most effective for patients who were older, had less formal education, and were less secure financially.

In conclusion, it would seem that psychological therapy of any kind is, in general, better than no therapy. Which kind of therapy is most effective probably depends on the particular problem that is to be treated, the socioeconomic background of the patient, and other patient variables. For example, whether a person believes in the effectiveness of a particular kind of therapy, or therapist, may be instrumental in determining therapeutic success.

Modifying Abnormal Behavior: Evolutionary Considerations

What can evolution theory add to our discussion of therapies for abnormal behavior? The gap between evolution and therapy may seem enormous, but certain predictions about the potential success of therapy follow from an evolutionary perspective.

One prediction is that therapies that take into account human *biological predispositions* for learning are more likely to succeed than are those that ignore such tendencies. We saw evidence consistent with this prediction earlier in the chapter. The use of electric shock as an aversive conditioning technique is ineffective in treating alcoholism. However, the use of chemical aversion has been effective in treating some in-patient alcoholics. A possible explanation for the difference in effectiveness is that humans, like certain other species, are biologically prepared through natural selection to associate the taste and smell of a substance with illness more readily than with *externally* produced pain (see Chapter 7).

Another prediction derived from an evolutionary perspective is that certain abnormalities, to the extent that they provide adaptive advantages, may be quite resistant to change. As we mentioned in Chapter 21, it may be a mistake to think that abnormal behavior is always maladaptive, at least in the Darwinian sense of the term. Some disorders may be rooted in our evolutionary past because they had survival value for our ancestors. Others may arise and be maintained because they offer ways to reduce anxiety, thereby contributing to survival. In either case such abnormalities may be difficult to eradicate. Currently there is little information on the *adaptive* consequences of various behavioral disorders.

A final prediction, one that could incorporate the first two, is that humans are *not* infinitely adjustable. This is a particularly important and perhaps crucial consideration in light of the significant changes we have brought about in our habitat. It could be argued that certain behavioral disorders are by-products of recent cultural evolution (Tinbergen, 1972), and that with continuing profound and rapid changes there will be more and more individuals who fail to make successful adjustments. Indeed, as a species, we may produce changes that exceed the limits of our adjustment potential, with the result that certain abnormal behaviors might someday become the *norm*, and therapy for such behaviors will become a hopeless and meaningless concept.

If this seems like an exaggerated or unreasonable position, consider the fact that industrial and technological advances are producing drastic changes in our habitat. Energy resources are now threatened, food chains are endangered, and the atmosphere and oceans are changing in undesirable ways, not to mention the psychological threat of nuclear disaster. Most important, many of the changes in the environment are happening at an extremely rapid pace. Warns Tinbergen, "Our conquest of the environment is causing habitat changes at a pace that genetic evolution cannot possibly match—not even if directed and speeded up by the, morally and practically doubtful, genetic engineering that some have proposed" (p. 226).

It is only recently that we have begun to recognize that there are indeed limits to human behavioral modifiability. Let us hope that this recognition will stimulate large-scale efforts to identify more precisely what those limits are, and what can be done to overcome them.

> The conclusion seems inescapable that we shall soon be faced with a task of "bio-engineering" for the purpose of restoring our adaptedness, or rather of re-establishing adaptedness at a new level. . . .
>
> In this task we cannot possibly succeed unless we know *in concreto* the new pressures we are creating, and how these pressures could be either met or reduced. . . . It will be the knowledge

> of behavior mechanisms, and of mechanisms of behavior development, that will have to form the basis for whatever engineering will have to be undertaken. . . No one can say how soon science will be called upon for advice, but if and when that time comes, we shall have to be better prepared than we are now (Tinbergen, 1972, pp. 226–27).

Supplement 1. A Humanist-Behaviorist Dialogue[*]

HUMANIST: The trouble with you behaviorists is that you see people as simply behaving organisms to be scientifically studied or therapeutically modified. You miss the person behind the behavior.

BEHAVIORIST: Well, that's a common idea about behavioral therapists and maybe some are that way, but it's a vast oversimplification to characterize all of us in that fashion. Your statement implies that we don't appreciate and respect people as human beings, seeing them only as objects to be studied and manipulated. What bothers me about you humanistic therapists is that you seem to feel that by applying the term ***humanistic*** to yourselves, you have a corner on the market for all humanistic concerns. How self-righteous can you get?

HUMANIST: OK, OK, I overstated the case. But I think you'll have to admit that *as a group* behavioral therapists, with their background in scientific psychology and their preoccupation with measurement and experimentation, have been more likely to take a detached, scientific attitude toward their clients than have, say, client-centered therapists.

BEHAVIORIST: True, but the point I'd like to make is that nothing in the behavioral point of view forces a therapist to have any less respect for a client or to care any less about reducing suffering than any other therapist would. Furthermore, I think the group difference that you mentioned may not exist in the newer generations of behavior therapists—thanks, perhaps, in part to the criticisms of people like yourself.

HUMANIST: I'm glad if we've had some effect. I'm still not sure that a behavioral approach is basically compatible with a humanistic valuing of the person.

BEHAVIORIST: Let me try another tack. So far I have been on the defensive, reacting to your claim that behaviorists are not concerned about people. When Lang and Melamed (1969) saved the life of an infant by devising a behavior modification procedure that stopped the infant from vomiting uncontrollably, would you tell me that they cared less about saving the infant's life than some other kind of therapist would have? But that is not my main point. Because of these therapists' behavioral orientation, they were able to develop a procedure that worked. Everything else had been tried with that baby, and he seemed doomed to die. If you are really concerned about relieving human suffering, then you have to be concerned about developing procedures that work. And that involves measurement, experimentation, and all that other "bad" stuff.

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[*] From Martin, 1981, pp. 173–75.

HUMANIST: Touché, or at least a partial touché. I know you could reel off quite a few examples of that kind. Your point is well taken and I accept it. But most psychotherapy these days is not done with nonverbal infants, or psychotics, or people with a highly specific symptom, such as a phobia. Most therapy clients are more broadly discontented with life and have feelings of worthlessness and lack of fulfillment. Although a mechanical apparatus may effectively stop a baby from vomiting or perhaps even remove a restricted phobia, it seems unlikely that anything so mechanical will ever work with these more complex problems in living.

BEHAVIORIST: OK, my turn to yield a point to you. But only a point, not the entire game. Actually, I believe that some of these more complex problems can be broken down into separate components such as self-derogatory statements, or inability to appropriately assert oneself, and behavioral technologies can be developed to modify them. I intentionally used the term *technologies* because I know it's like waving a red flag in front of a bull. It confirms your belief that we view therapy as a depersonalized technology like bridge building rather than some kind of unique, almost mystical, experience between two human beings. But don't forget, it was a technology that saved the baby's life, and what I am now proposing is that technologies can help people with more complex difficulties, such as low self-esteem. And since we are strongly committed to evaluating whether our technologies work, we may in the long run be able to help people more effectively than you to raise their self-esteem, develop their full potentials, free themselves from narrow societal expectations, or any other humanistic goals you might want to specify.

HUMANIST: Well, maybe. Don't forget that Carl Rogers, a humanistic therapist, was also one of the first people to attempt to evaluate the effectiveness of psychotherapy. There is some reason to believe that even your technologies work best when conducted by therapists who are warm, sensitive, have a sense of humor, and treat their clients with respect.

BEHAVIORIST: You're probably right about that, and behavior therapists are more concerned about these characteristics, what they sometimes refer to as "soft clinical skills," than they used to be. That is certainly another point for the psychodynamic and humanistic therapists. I would stress, however, that characteristics such as warmth and respect represent a kind of baseline that is necessary for the effective use of more specific procedures. Cold, insensitive, uncaring therapists are not likely to be effective, no matter what they do. At the same time, many clients are not likely to be helped by simply sitting with a warm, sensitive, respecting therapist. The therapist must exercise some technical competence in addition to being a beautiful person. On this point, psychoanalytic therapists would be in strong agreement with behavior therapists.

HUMANIST: I can go along with most of what you're saying, although we may continue to differ on the relative emphasis on the quality of the relationship with the therapist as opposed to change-producing technologies. We humanists will have served a useful purpose if we have made it more difficult for therapists of any persuasion to forget that they are trying to help people, not just shape behavior.

Another drawback to the behavioral approach is that most of your procedures tend to further cut persons off from their subjective experiencings. You desensitize the person's fear of public speaking but never give the person a chance to fully explore all the cut-off experiencings associated with this fear — possibly preventing individuals from enriching their personalities through a fuller integration of different aspects of themselves.

BEHAVIORIST: That may reflect a real difference in our metaphors of human psychology. Certainly the idea of expanding and enriching the domain of subjective experiencing has not been given much importance by behaviorists. On the other hand, to return to your example, it may be that as a result of having the fear associated with public speaking removed, the person is now free to experience life more fully, including the satisfactions of public speaking.

Now there's one other question I want to raise. Humanistic-existential therapists keep introducing the issue of free will and determinism into their discussions, usually by accusing the behaviorists, and psychoanalytic therapists too, of further dehumanizing their clients by seeing their behavior as completely determined, by denying them free will. Now, the question of free will is a subtle one about which philosophers themselves have not as yet come to any generally acceptable solution. When therapists, humanistic or behavioral, engage in amateur philosophizing about this question, I strongly suspect that a good deal of naïveté is involved. It is emotionally appealing to see ourselves in control of our destiny by making "free" choices. But because something is emotionally appealing doesn't make it so. My point here is not to argue for or against some form of free will or determinism, but to say that there are various sophisticated, philosophical positions on these issues, most of which are quite compatible with the basic features of a behavioral approach.

HUMANIST: You may be right about the subtleties of the free-will issue. I would argue, however, that it can make a difference if a therapist is communicating to a client that the client can make decisions and be responsible for them, as opposed to a message that the client's behavior will be changed as a result of the external manipulation of contingenices.

BEHAVIORIST: I agree. In fact current behavior technologies are much concerned with the question of how to help the person gain more self-control. But to return to my initial point, a therapist can be concerned about creating conditions that maximize the client's taking responsiblity without having to take a position on the philosophical issue of free will. As a matter of fact, I have my own amateurish thought about free will and determinism: at some point B. F. Skinner and Zen Buddhism (unlikely bedfellows!) converge to the same position. With Zen enlightenment one realizes that everything is determined and that each one of us is part of that determining process. We can have it both ways, in other words. God, or if you'd rather, Ultimate Reality, determines everything and we are part of God.

HUMANIST: You're beginning to sound more like a muddleheaded humanist than a hard-nosed behaviorist. Perhaps we've taken this discussion as far as we can for now.

Glossary

Abnormal behavior Culturally inappropriate behavior that often involves subjective distress and can involve impaired functioning in carrying out routines of daily life.

Abscissa In statistics, the horizontal axis of a graph.

Absolute refractory period The first part of the refractory period after an impulse passes a neuron during which time the neuron cannot fire. See **relative refractory period.**

Absolute threshold The lowest level of stimulus intensity that can be detected by a receptor.

Accommodation (1) The ability of the lens of the eye to flatten or bulge in order to focus on objects at varying distances; (2) a monocular cue to depth that results from that adjustment; (3) in Piagetian theory, resolving a new problem by changing schemes or concepts. See **assimilation.**

Acquired taste aversion Avoidance of a particular food because the taste of the food is associated with illness.

Adaptation (1) In Piagetian theory, the innate tendency to resolve uncertainty (achieve equilibration) by means of assimilation and accommodation; (2) an adjustment to a recurring stimulus; (3) a genetic feature that has survival value in a particular environment or type of environment.

Affective disorders A category of psychological disorders according to DSM III that, given the circumstances, involve inappropriate mood states.

Afferent neurons Neurons that transmit impulses to the central nervous system; they are sensory in function. See **efferent neurons.**

Affiliation Bringing or receiving another person into a close relationship.

Aggression Behavior directed toward others that could lead to their harm and often results in deciding access to resources, or status.

Agonistic behavior A type of contest competition that includes threat, counterthreat, attack, counterattack, defense, submission, and escape.

Aldosterone A hormone released by the adrenal cortex that acts to make the kidney more permeable to salts that are recovered from the urine when the body is short of water.

Alleles Different forms of the same gene; alternatives at one position on a chromosome (or homologous chromosomes).

Alpha wave Activity recorded on an electroencephalogram (EEG) consisting of a fairly regular pattern of brain waves that are relatively low in frequency and high in voltage; typically observed when a person is awake and relaxed, with eyes closed.

Altricial birds Birds that are helpless at hatching and remain in the nest for some time. See **precocial birds.**

Altruism Helping others without expectation of receiving a benefit or reward. The term is often used incorrectly.

Amniotic fluid The liquid medium that protects the embryo from physical trauma during its prenatal existence.

Amniotic sac The protective covering that surrounds the embryo; it develops between the third and eighth week after fertilization.

Amygdala An almond-shaped group of nuclei in the brain involved in aggression and other emotional behaviors.

Anal stage In psychoanalytic theory, the second stage of psychosexual development (1½–3 years), during which libido is focused on the anus and anal activities.

Anatomical Structural.

Androgen A male sex hormone.

Angiotensin A hormone converted from agiotensinogen in the bloodstream by the presence of renin. Angiotensin causes thirst.

Anterior The head end; also called rostral and cephalic.

Antianxiety drugs Minor tranquilizers including Miltown, Librium, and Valium that are used to treat neurotic disorders such as anxiety.

Antidepressent drugs Stimulants used to treat severe depressive reactions.

Antidiuretic hormone (ADH) A hormone secreted by the pituitary gland that recovers liquid from the kidneys when the body experiences a shortage of water.

Antipsychotic drugs Major tranquilizers including Thorazine, Stelazine, and other phenothiazines that are used to treat psychotic disorders.

Antisocial personality A personality disorder according to DSM III characterized by lack of anxiety or guilt feelings over wrongdoing, low tolerance for frustration, apparent charm, and inability to feel empathy for others.

Aphasia Speech disorder.

Applied psychology The application of basic theory and research to problems people face in daily existence.

Archetype According to Jung, a universal tendency to think or act in certain ways inherited from our ancestors and present in the unconscious mind.

Artificial selection When humans, instead of nature, determine which animals will mate and reproduce.

Ascending tracts Bundles of axons within the CNS that carry impulses anteriorly (toward the head).

Asexual reproduction Reproduction that occurs in unicellular organisms without the benefit of a mate.

Assimilation In Piagetian theory, resolving a new problem by using existing schemes or concepts. See **accommodation.**

Association The phenomenon in which a specific stimulus elicits a specific response as a result of repeated pairing.

Association areas Areas of the cerebral cortex, neither sensory nor motor, that integrate sensory commands and motor commands.

Attachment The development, by about seven months of age, of an emotional bond between infant and caregivers.

Auditory nerve The neurons in the cochlea that conduct impulses to the brain.

Auditory ossicles Three small bones of the middle ear (malleus, incus, and stapes) that conduct vibrations from the tympanum to the oval window.

Autonomic nervous system (ANS) The efferent visceral components of the peripheral nervous system, which controls internal organs, somewhat autonomously (independently) of the central nervous system; the ANS includes the sympathetic and parasympathetic nervous systems.

Autoshaping The self-shaping of an apparent instrumental response due to repeated pairings of a stimulus with access to reinforcers. The phenomenon is better explained by classical conditioning than by instrumental learning principles.

Aversive Unpleasant, repulsive, repugnant.

Aversive conditioning A behavior therapy that seeks to countercondition an aversion for an object of attachment or dependence.

Aversive stimulus In instrumental learning, a stimulus which, when removed or prevented, is associated with an increase in the strength of the response that preceded it.

Axon The (often) long part of a neuron that transmits impulses to other neurons, or to muscles or other organs.

Babbling Vocalizing by infants starting about four months of age that involves repeating sequences of sounds.

Basic psychology Psychological theory and research related to the fundamental processes of behavior; the what, how, and why of behavior.

Basilar membrane The membrane that divides the cochlea of the inner ear, to which are attached the organs of Corti.

Behavior The overt and covert activities of an organism.

Behavior genetics The area of specialization concerned with the nature and the degree of hereditary influences on behavior.

Behaviorism The approach to psychology which, under the influence of John B. Watson, rejected the study of conscious experience, and limited itself to the investigation of observable, measurable behavior.

Behavior therapy Therapies based on classical conditioning, instrumental learning, and observational learning.

Beta wave Activity recorded on an electroencephalogram (EEG) consisting of an irregular pattern of brain waves that are relatively high in frequency and low in voltage; typically observed when a person is in an alert, attentive state, as when engaged in problem solving.

Between-subjects design An experimental design in which the researcher assigns subjects randomly to the different conditions of the independent variable. See **within-subjects design.**

Bipolar cells The middle layer of the retina that passes nerve impulses from the rods and cones to the ganglion cells on the inner layer.

Bipolar disorder A major affective disorder according to DSM III that includes mood swings from mania to depression.

Blastocyst In human development, the grouping of cells during the period of the ovum that attaches to the wall of the uterus.

Blindspot The point at which the optic nerve passes out of the eyeball.

Bond A positive relationship between individuals.

Brain The complex mass of nerve cells and related cells encased in the skull.

Brainstem The structure that connects the forebrain with the spinal cord; it includes the medulla, pons, midbrain, and reticular formation.

Brainstorming A type of group problem solving in which individuals are encouraged to propose as many unusual ideas as they want in a nonthreatening atmosphere; designed to elicit creative solutions to problems.

Brightness The psychological term relating to the physical property of luminance; intensity. See **hue, saturation.**

Broca's area The language area of the brain that regulates speech production. See **Wernicke's area.**

Carnivores Meat eaters

Case history An assessment tool that provides historical information about a person, part of which is typically obtained during an interview and part of which is obtained from other sources.

Case study A research method in which the investigator seeks background information through interviews with the person and his or her relatives, acquaintances, and other interested parties.

Catatonic schizophrenia A form of schizophrenia sometimes characterized by long hours spent in a motionless, withdrawn, mute, trancelike state.

Cell The structural unit of animal life containing a nucleus and cytoplasm enclosed in a membrane.

Central fissure The crevice that separates the frontal lobe from the parietal lobe in the cerebral hemispheres of the brain.

Central nervous system (CNS) The brain and spinal cord.

Central tendency In statistics, the balance point of a distribution of scores; specifically the mean, median, and mode.

Centromere The portion of the chromosome at which the spindle is attached during cell division.

Cephalocaudal principle The principle that physical development proceeds sequentially from head to toe.

Cerebellum The brain structure located just to the rear of the medulla. In mammals it controls equilibrium, posture, and motor coordination.

Cerebral cortex The thin outer covering of the cerebrum; includes sensory, association, and motor areas.

Cerebral hemispheres The two nearly symmetrical halves of the cerebrum in humans and other mammals, separated by the longitudinal fissure and connected by the corpus callosum.

Cerebrum A part of the telencephalon; it is divided into left and right hemispheres, which cover most of the rest of the brain, and includes the major coordinating centers of the nervous system.

Chemotherapy The use of chemicals (drugs) to treat certain abnormal behaviors.

Chromosome A strand of DNA including a number of genes.

Chunking A memory process that involves combining several different items to form a higher-order unit (a chunk) of information.

Ciliary muscles Muscles of the eye that focus the lens.

Circadian rhythms Daily biological rhythms that correspond to periods of light and dark, such as sleep and waking.

Classical conditioning A form of learning in which a reflex becomes associated with a new stimulus, one that had never before elicited the response.

Closure A Gestalt principle of perceptual organization, the tendency to perceptually "fill in" missing parts of a pattern.

Cochlea The liquid-filled spiral tube of the inner ear that conducts pressure from the oval window to the hair cells in the organs of Corti.

Co-dominant A term applied to alleles, neither of which is dominant (nor recessive) to the other, both of which express themselves in the phenotype.

Cognition The act of knowing, or the product of this act. In psychology, the mental activities that constitute thinking, including sensing, perceiving, learning and remembering, conceptualizing, reasoning, problem solving, and imagining.

Cognitive dissonance Festinger's theory that inconsistent cognitions result in tension that motivates a person to attempt to remove the inconsistencies, thereby reducing the tension. Such attempts usually result in changing one's cognitions or behaviors, and may be perceived by others as self-justification or rationalization.

Cognitive structure In Piagetian theory, a set of interrelated and highly organized schemes.

Collective unconscious According to Jung, a part of the unconscious made up of archetypes that include experiences common to all humanity.

Communication A transfer of information from one individual to another through tactile, chemical, auditory, or visual signals.

Component theory of color vision The belief that perception of color is due to the addition of sensations from three different sets of receptors; one sensitive to "yellow-green," another sensitive to "green," and a third sensitive to "violet" wavelengths. See **opponent theory of color vision.**

Concept A unitary mental representation of stimuli that are related in some way.

Conception Union of ovum and sperm.

Concrete operation In Piagetian theory, the third stage of cognitive development (7–11 years), characterized by the acquisition of logical reasoning (operational thought).

Conditioned response (CR) In classical conditioning, a response similar to the unconditioned response that comes to be elicited by the conditioned stimulus (CS).

Conditioned stimulus (CS) In classical conditioning, a previously neutral stimulus that becomes associated with the unconditioned stimulus (UCS).

Cone One of the color-sensitive photoreceptive cells located in the retina of the eye that converts light energy into nerve impulses. See **rod.**

Conscious In psychoanalytic theory, the part of the mind concerned with immediate perceptions and those things that can be recalled with no difficulty. See **preconscious unconscious.**

Conscious experience The sum of the perceptions, thoughts, dreams, and feelings in one's awareness.

Conservation In Piagetian theory, the ability of children in the stage of concrete operations to recognize the stability of a quantity even though it undergoes changes in its perceptual configuration.

Contest competition A form of competition that involves the direct interaction of individuals seeking resources when the outcome determines who gets the resources. See **scramble competition.**

Contingency management A behavioral therapy based on instrumental learning principles which involves managing the positive reinforcers that bring about desired or undesired behavior.

Continuous reinforcement schedule (CRF) In instrumental learning, reinforcement that always occurs after every correct response.

Convergence (1) When both eyes turn toward each other in a coordinated fashion in order to focus on an object; (2) the binocular cue to depth, based on the eyes, turning to fixate on an object.

Convergent thinking Thinking in which a problem solver considers different logically possible solutions with the aim of arriving at a single solution. See **divergent thinking.**

Conversion disorder A form of somatoform disorder that includes symptoms such as paralysis, disturbances in vision or hearing, and loss of sensitivity to stimuli of the skin, all without known organic pathology.

Cornea The bowed and transparent covering of the lens through which light enters the eye.

Corpus callosum A large group of nerve fibers that connect, and allow communication between, the two cerebral hemispheres.

Correlation coefficient In statistics, the measure of strength of a relationship or correlation among two or more variables represented by a number that can vary from 0 (no correlation) to ± 1.00 (perfect correlation).

Cortical columns Visual cortex nerve cells that respond to different stimuli.

Counterconditioning In classical conditioning and instrumental learning, the process of weakening an unwanted response by eliciting or reinforcing a response that is incompatible with the unwanted response.

Countertransference In psychoanalytic therapy, the development by the therapist of strong positive or negative feelings toward the patient. See **transference.**

Covert activities Internal behavior that must be inferred from observation.

Critical period A genetically influenced and well-defined period of rapid development of organ systems or systems of behavior, during which those systems may require certain environmental inputs for normal development, and are highly susceptible to these and other environmental influences. See **sensitive period.**

Crossing over An exchange of equal parts (groups of genes) between homologous chromosomes that occurs during meiosis I.

Cross-sectional research A research design that involves the observation of a number of groups on one occasion, each group representing a different age level. See **longitudinal research.**

Culture Traditional modes of thinking and behaving that are passed from one generation to another by social learning.

Cytoplasm The substance of a cell exclusive of the nucleus.

Decenter In Piagetian theory, the ability to think about things beyond immediate sensory experience in an objective and realistic manner.

Deductive method An approach to reasoning that proceeds from general principles to particulars. See **inductive method.**

Delta waves Activity recorded on an electroencephalogram (EEG) consisting of very regular waves at certain times that are lower in frequency and higher in voltage than alpha waves; become increasingly prominent as a person goes into periods of deep sleep.

Delusion An irrational belief.

Dementia Deterioration in thinking and judgment.

Dendrites Highly branched parts of neurons that detect stimuli, either from receptors or other neurons.

Deoxyribonucleic acid (DNA) The complex molecules that appear within chromosomes, which provide basic hereditary information.

Dependent variable In an experiment, the factor that varies with (depends on) the different values of the independent variable.

Depolarization An increase in a neuron's permeability to sodium ions (Na +) that can result in a nerve impulse.

Descending tracts Bundles of axons within the CNS that carry impulses posteriorly (toward the tail).

Descriptive statistics Statistical measures that describe in an economical manner patterns, trends, and relationships in data.

Desensitization A behavior therapy in which the client is confronted repeatedly with the feared stimulus (as in flooding) with an accompanying attempt at counterconditioning.

Development Growth or change related to age; a result of the interplay between inherited (genetic) conditions and environmental events.

Developmental psychology The area of specialization within psychology concerned with understanding changes in behavior that are related to age.

Dichotic listening A listening task in which the subject hears a different message in each ear and is asked to attend to one.

Diencephalon The structure of the brain that includes the thalamus, the hypothalamus, and epithalamus.

Dimorphic A term applied to species in which males and females appear strikingly different in certain characteristics such as plumage color. See **monomorphic.**

Discrimination (1) In classical conditioning, when a given conditioned response (CR) is elecited by one stimulus, but not by another; (2) in instrumental learning, whenever an instrumental response is made in the presence of one stimulus, but not in the presence of another.

Discriminative stimulus (S^D) In instrumental learning, identifiable aspects of the learning environment that have been associated with reinforcement or punishment, and are capable of controlling behavior because of that association.

Dishabituation The recovery of an habituated response following the presentation of a different (usually intense) stimulus.

Display rules Socially approved ways of expressing emotion that are learned from one's culture.

Dissociative disorders A category of psychological disorders according to DSM III that includes psychogenic amnesia, psychogenic fugue, and multiple personality.

Divergent thinking Thinking in which a problem solver explores several different, often seemingly unrelated, ideas, with no necessity of finding one particular solution in the end. See **convergent thinking.**

Dizygotic twins Twins that develop from two separate fertilized eggs. Called fraternal twins, 50 percent of their genetic information is shared. See **monozygotic twins.**

Dominance Attribute of an allele that expresses itself (causes the appearance in the phenotype of the characteristic it influences), either pure or mixed.

Dopamine A neurotransmitter involved in the regulation of certain motoric and emotional behaviors.

Dorsal Related to or located on or near the back of an animal.

Double-blind technique A way to control for bias in an experiment by keeping both the subject and the observer uninformed about the particular treatment that the experimenter will administer. See **single-blind technique.**

Dream interpretation A psychoanalytic technique that involves reporting of dreams by the patient; the dreams are believed to provide insights into the unconscious.

Drive An energizing internal condition that can arise because of an unmet need or a disruption in homeostasis caused by an intense stimulus.

Drive reduction theory The theory that explains motivation as an effort by an organism to reduce the "tension" associated with an aroused drive.

Echoic memory Briefly-held information in the auditory sensory register. See **iconic memory.**

Ectoderm In human development, a layer of tissue that differentiates and gives rise to the outer layer of skin, skin glands, sensory cells, fingernails, hair, parts of teeth, and nervous system.

Ectomorphy According to Sheldon, a lean body type associated with being introverted and inhibited. See **endomorphy; mesomorphy.**

Ego In psychoanalytic theory, a component of personality that is rational and accepts delayed gratification in an attempt to satisfy the id in a realistic fashion. See **id; superego.**

Egocentrism In Piagetian theory, the inability of children to recognize the existence of points of view other than their own.

Efferent neurons Nerves that transmit impulses from the central nervous system to organs or muscles; they are motor in function. See **afferent neurons.**

Ego defense mechanisms In psychoanalytic theory, rational and irrational methods employed by the ego to reduce anxiety. Although they may be effective, the mechanisms are unrealistic because they tend to distort reality.

Electroencephalogram (EEG) A record of brain wave activity normally made from electrodes attached to various parts of the scalp.

Electromyogram (EMG) A record of muscle activity normally made from electrodes attached to various skeletal muscle locations.

Electro-oculogram (EOG) A record of eye movements normally made from electrodes attached to the skin surrounding the eye.

Electroshock therapy (EST) An electrically induced brain seizure for treating severe depression.

Embryo, period of In human development, the third to the eighth week after fertilization characterized by rapid development and differentiation of various mammalian characteristics such as a head, tail, gill arches, eye lens, and limbs.

Embryology The study of embryos and their development.

Empirical Derived from sensory experience or observation rather than from theory, speculation, faith, or some other nonsensory means.

Endocrine system The many glands in different parts of the body that control and integrate several body functions by releasing into the bloodstream hormones that affect organs elsewhere in the body.

Endoderm In human development, a layer of tissue that differentiates and gives rise to the gastrointestinal tract, trachea, bronchia, lungs, pancreas, liver, glands, and other internal organs. See **ectoderm; mesoderm.**

Endomorphy According to Sheldon, a fat body type associated with being extroverted and sociable. See **extomorphy; mesomorphy.**

Endorphin An opiumlike substance secreted in times of stress that reduces sensitivity to pain.

Enkephalen An opiumlike substance secreted in times of stress that reduces sensitivity to pain.

Environmental psychology An applied branch of psychology that seeks ways to understand the effects of people's environments on behavior and to improve the quality of our environments.

Episodic memory Memory in the long-term store consisting of temporally and spatially coded information and events. See **semantic memory.**

Epistemology The study of the nature of knowledge.

Epithalamus Part of the diencephalon; it includes the pineal body.

Equilibration In Piagetian theory, the process of attaining cognitive balance; a resolution of uncertainty attained through assimilation and accommodation.

Equity theory An extension of social exchange theory that stresses the discomfort people often feel when costs and rewards do not balance out, either for themselves or for others.

Eros In psychoanalytic theory, the category of life-perpetuating and life-sustaining instincts including sex, survival, and the instincts to obtain food, water, and other necessities. See **Thanatos.**

Estrogen A female sex hormone.

Eugenics A discipline, or movement, dedicated to improvement of the human race through encouragement of selective mating.

Eustachian tube The tube that connects the middle ear to the throat, through which the air pressure in the middle ear is kept about the same as the air pressure outside the body.

Evolution Changes in gene frequencies that result in changes in the genetic constitution of populations through time.

Excitatory postsynaptic potential (EPSP) The depolarization of a receiving neuron prompted by the release of neurotransmitter from a neighboring neuron. See **inhibitory postsynaptic potential.**

Experimental method The systematic manipulation of the conditions or variables that are thought to affect a phenomenon for purposes of understanding the causes of that phenomenon.

Extinction In classical conditioning, the gradual decline in a conditioned response (CR) as a result of presenting the conditioned stimulus (CS) alone over and over again. In instrumental learning, the gradual decline in a response following removal of the reinforcer.

Extrovert According to Jung, a personality type characterized by focus of the libido toward objects and other people; an outgoing, sociable individual. See **introvert.**

Fechner's Law The observation that the magnitude of sensation perceived equals the logarithm of the intensity of stimulus, multiplied by a constant; $S = K \log R$.

Fetus, period of In human development, the final stage of prenatal life, which lasts from 8 weeks to approximately 38 weeks (birth).

Figure-ground A Gestalt principle of perceptual organization: things that stand out from surrounding stimuli are called figure; the background stimuli are called ground.

Fitness Biological success; survival and the production of successful offspring.

Fixation In psychoanalytic theory, a continuous preoccupation with the particular means of obtaining pleasure associated with the oral, anal, or phallic stage long after the child normally would pass to another stage.

Fixed-interval (FI) schedule of reinforcement In instrumental learning, reinforcement that occurs after the first correct response following the passage of a set amount of time.

Fixed-ratio (FR) schedule of reinforcement In instrumental learning, reinforcement that always occurs after the same number of responses.

Flooding A behavior therapy that is based on extensive involvement (direct or indirect) with the feared stimulus until the anxiety subsides.

Forebrain The diencephalon, which attaches to the brainstem, and the telencephalon.

Formal operations In Piagetian theory, the fourth stage of cognitive development characterized by the ability to reason abstractly.

Fovea The small spot on the retina where a sharp image is formed.

Free Association A psychoanalytic technique in which the patient is encouraged to say whatever comes to mind as a way of revealing the unconscious.

Frequency distribution In statistics, the particular arrangement of multiple score values of some characteristic.

Frontal lobe The anterior portion of the cerebral cortex of each hemisphere.

Frustration-aggression hypothesis Dollard's original view that every frustration produces aggression and every aggression can be traced back to frustration, which has been modified to allow for other responses to frustration.

Fugue A dissociative disorder that involves physical flight or withdrawal from a situation that often accompanies psychogenic amnesia.

Functional fixedness In problem solving, a condition that results when perception of an object's normal functions keeps a problem solver from discovering new ways in which to utilize the object.

Functionalism The approach to psychology in which the mind and behavior were viewed as adaptive processes or functions. See **structuralism.**

Gamete An ovum (egg) or sperm.

Ganglion One of a group of neuron cell bodies that appears as a bulge or swelling on a nerve.

Generalization gradient In classical conditioning, the function relating conditioned response (CR) probability to degree of similarity of a stimulus to the conditioned stimulus (CS).

Generalized anxiety disorder Chronic and long-lasting symptoms of anxiety that do not appear to be associated with any specific stimulus.

General paresis A mental disorder characterized by delusions, dementia, and progressive paralysis resulting from syphilis.

Genes Carriers of hereditary information affecting particular characteristics that are arranged in a linear sequence, forming a chromosome.

Genetic isolation Behavioral or physical characteristics that prevent members of two groups from interbreeding successfully when the two groups are in the same geographic area. See **geographic isolation; isolating mechanisms.**

Genetics The scientific study of heredity.

Genital stage In psychoanalytic theory, the final stage of psychosexual development (adolescence and adulthood), in which the libido is focused primarily on heterosexual relationships.

Genotype The genetic constitution of an individual; the term may refer to one or more genes.

Geographic isolation A separation in space of sufficient distance that members of one group cannot breed with members of the other group. See **Genetic isolation; isolating mechanisms.**

Gestalt psychology The approach to psychology that emphasizes the dynamic configurations (*Gestalten*) of conscious experience and behavior.

G-factor The presumed innate single general factor in Spearman's two-factor theory of intelligence.

Gonads The sex glands; testes in males and ovaries in females.

Good continuation A Gestalt principle of perceptual organization in which elements that continue the direction of other elements in a figure tend to be perceived as belonging to a group.

Gustation Tasting; the sense of taste.

Habituation The simplest form of learning; a process in which repeated presentations of a stimulus bring about a gradual decline in the response.

Hallucination Hearing, seeing, or otherwise sensing things that do not exist.

Herbivores Plant eaters.

Heterozygous The description of a characteristic when the genes influencing that characteristic are different alleles.

Heuristic search strategies Problem-solving strategies that are selective; they do not test all logically possible solutions, but do test those that seem to have a high probability of producing a correct solution. See **random search strategies.**

Higher-order conditioning In classical conditioning, a means of attaching a conditioned response (CR) to a stimulus other than the original conditioned stimulus (CS) through additional conditioning experiences. See **secondary reinforcement.**

Hippocampus A part of the limbic system involved with learning and memory.

Homeostasis The tendency to maintain a rather stable internal environment, such as body temperature.

Hominoid A member of the superfamily *Hominoidea,* which includes living apes, such as the chimpanzee, gorilla, and orangutan, as well as humans.

Homologous chromosomes A pair of chromosomes including the genes, which affect the same characteristic (but often affect that characteristic in different ways).

Homozygous The description of a characteristic when the genes influencing that characteristic are identical.

Hormone A substance produced by an endocrine gland in one part of the body that has one or more specific (and often profound) effects in another part of the body.

Hue The psychological perception of the visible wave lengths of light that is often referred to as color. See **brightness; saturation.**

Hybrid The result of a cross between two species.

Hyperpolarize To raise the threshold of a neuron by making the membrane of the dendrite less permeable to sodium ions.

Hypothalamus A part of the diencephalon that monitors and influences several aspects of the internal environment and is involved with hormone secretion, biological motivation, and emotional behavior.

Hypothesis A prediction or educated guess about the answer to a research question.

Hysteria A broad class of mental disorders characterized mainly by physical symptoms with no apparent organic cause.

Iconic memory Briefly-held information in the visual sensory register. See **echoic memory.**

Id In psychoanalytic theory, a component of personality that contains the libido, is hedonistic in nature, and seeks immediate gratification. See **ego; superego.**

Imprinting In young animals, the process of forming a social attachment, usually to the parent, as a result of experience during a sensitive period of development.

Incest The mating of close relatives.

Inclusive fitness Fitness that includes personal fitness as well as the fitness of relatives.

Incubation In problem solving, a period of time spent away from a problem, which is associated with the discovery of a solution to that problem.

Incus One of the small bones in the middle ear called the anvil. See **auditory ossicles.**

Independent assortment During meiosis I, the pairs of chromosomes each individual received from his or her parents (one member of a pair from each parent) assort into the gametes independently of each other in new pairs so that each gamete receives one complete set of chromosomes, some from each parent.

Independent variable In an experiment, the environmental factor manipulated by the researcher in order to observe the effect on another factor called the dependent variable.

Inductive method An approach to reasoning that proceeds from particular observations to general principles. See **deductive method.**

Infancy The first two years of human life after birth.

Inference A conclusion or deduction that follows from observational data and provides some insight into that data.

Inferential statistics A quantitative method of determining the probability that what is observed in a sample actually reflects reality in the population from which the sample was selected.

Inferior colliculi Important relay nuclei for the auditory system in mammals that may be involved in coordinating auditory reflexes.

Information processing model An attempt to explain thinking in terms of the operations of computers.

Inhibitory postsynaptic potential (IPSP) The hyperpolarization of a receiving neuron prompted by the release of neurotransmitter from a neighboring neuron. See **excitatory postsynaptic potential.**

Innate Behavior that is unlearned, but may be subject to modification through learning or other environmental influences.

Innervate Supply with nerves.

Instinct A relatively complex behavior or disposition that is innate; also called fixed action pattern or species-typical behavior. See **reflex.**

Instinctive drift A phenomenon in which an animal conditioned to engage in a specific learned response gradually drifts into instinctive behaviors characteristic of the species.

Instrumental learning Learning that occurs because of the consequence (stimulus) that follows a response.

Insulin A hormone essential for moving sugar into cells, thus providing them with material for energy.

Intelligence The basic ability to adapt to the environment.

Interference theory of forgetting The theory that information is lost from the short-term memory store because new events disrupt the retention of previous items.

Interneuron A neuron that transmits impulses between two or more other neurons.

Interposition A monocular cue to depth that occurs when close objects in the same line of vision partially cover ones farther away.

Interview An assessment tool that ranges from highly structured questions and answers to open-ended discussions.

Introspection The systematic reporting by subjects of inner mental and emotional states; the method used by Wilhelm Wundt to further the goal of structuralism.

Introvert According to Jung, a personality type characterized by an inward focus of the libido; an inhibited, unsociable individual. See **extrovert.**

In-utero In the uterus.

Invertebrates Animals without a vertebral column (backbone).

Ion An atom or group of atoms that carries a positive or negative charge.

IQ Intelligence quotient; Mental Age (MA)/Chronological Age (CA) × 100.

Iris The colored portion of the eye that surrounds the pupil and controls the amount of light that enters the eye.

Isolating mechanisms Factors that prevent the interbreeding, or successful interbreeding, between two groups when they are together. See **genetic isolation; geographic isolation.**

Justice motive The idea that the way people react to someone in distress depends on whether they think he or she deserves to be in such a situation.

Just noticeable difference (jnd) The amount of change required in a stimulus for it to be recognized by the subject. See **Weber's Law.**

Kinesthesis Sensory information about skeletal movement provided by receptors in the muscles, tendons, and joints.

Kin selection The idea that it is advantageous (of selective value) to help those to whom one is related.

Language A system of symbols and meanings organized according to rules and used in communication.

Latency stage In psychoanalytic theory, the fourth stage of psychosexual development (5½–12 years), in which the libido is dormant.

Lateral Toward the side.

Lateral cerebral fissure The crevice that separates the temporal lobe from the frontal lobe of the cerebral cortex.

Lateral hypothalamus (LH) A region in the hypothalamus associated with feeding. When this excitatory center is stimulated, test animals will eat. See **ventromedial hypothalamus.**

Lateralization The tendency for the cerebral hemispheres to be specialized for different functions.

Law of effect Thorndike's requirement for instrumental learning, which states that any response (R) that brings about "satisfaction" in a certain stimulus situation (S) will be strengthened.

Law of exercise Thorndike's statement that the stimulus-response connection will be strengthened as a result of practice.

Law of Prägnanz A Gestalt principle of perceptual organization translated as "good figure," meaning that perceptions are organized so that forms or patterns appear as simple and orderly as possible.

Learning Acquisition and retention of information resulting from experience.

Learning sets Strategies that produce a solution that will generalize to several different problems; acquired as a result of experience with many different problems requiring the same kind of solution.

Lens The structure of the eye immediately behind the cornea that focuses images on the retina.

Levels-of-processing A model of memory in which the capacity and duration of memory is dependent on the "depth" of processing the information receives when it is perceived. See **multi-store model.**

Libido According to Freud, psychic energy that impels an organism to act in ways that will promote self-preservation and propagation of offspring.

Limbic system A group of structures in the telencephalon that are involved in smell, emotion, motivation, arousal, and memory.

Linear perspective A monocular cue to depth based on the appearance of convergence as parallel lines get farther away.

Linguistic determinism The idea that language precedes and determines thought.

Linguistic relativism The idea that different languages produce different perceptual and cognitive views of the world.

Lithium carbonate A drug used to treat manic symptoms of bipolar disorder.

Longitudinal fissure The crevice dividing the two hemispheres of the cerebrum.

Longitudinal research A research design that involves observation of the same group of subjects over a period of time. See **cross-sectional research.**

Long-term memory The third memory store in the multi-store model of memory; an essentially unlimited capacity store. See **sensory register; short-term memory.**

Major affective disorders A category of psychological disorders according to DSM III that includes bipolar disorder and major depression.

Major depression A major affective disorder according to DSM III characterized by severe sadness and loss of contact with reality.

Malleus One of the small bones of the middle ear called the hammer. See **auditory ossicles.**

Maturation The hereditary process that governs the development of physical structures.

Mean In statistics, the sum of the scores in a given distribution divided by the number of scores comprising that distribution $\overline{X} = \frac{\Sigma X}{N}$.

Medial Toward the middle.

Median In statistics, the point that divides a distribution into two parts, such that 50 percent of the scores lie above it and 50 percent below.

Medulla The rear of the brain that connects with the spinal cord; it functions in feeding, digestion, breathing, and heart control.

Meiosis The type of cell division that results in gametes.

Memory The internal cognitive processes involved with storing, retaining, and retrieving information.

Memory trace An inferred physical change in the nervous system that is the basis for memory.

Mental age (MA) The score on an intelligence test expressed in years and months; the average age of individuals who performed at the same level as the person taking the test.

Mental retardation Significantly below-average intellectual functioning combined with deficits in adaptive behavior that become apparent during childhood or adolescence.

Mental set In problem solving, a phenomenon in which reliance on previously successful strategies hinders the solution of a new problem.

Mesoderm In human development, a layer of tissue that differentiates and gives rise to the inner layer of skin, skeleton, skeletal muscles, excretory, and circulatory systems. See **ectoderm; endoderm.**

Mesomorphy According to Sheldon, a muscular body type associated with being aggressive, adventurous, and assertive. See **ectomorphy; endomorphy.**

Metacognition Awareness and knowledge an individual has about his or her own cognitive abilities and functions; cognition about cognition.

Metamemory Metacognition related to memory.

Method of loci A memory strategy that involves associating a list of items to remember with a list of places already familiar.

Methylphenidate A stimulant drug used to reduce symptoms of hyperactivity in children.

Midbrain The portion of the brain between the pons and the diencephalon that controls eye activity and is involved in visual perception.

Mind–body dualism The view that the mind and body are separate entities in which the mind is considered to be synonymous with the soul instead of part of the brain.

Mitosis The type of cell division that occurs during growth or wound healing.

Mnemonic technique A strategy for remembering something. See **method of loci.**

Mode In statistics, the score that occurs most frequently in a distribution.

Model In science, the attempt to explain something unknown in terms of principles that are already well understood.

Modeling In instrumental learning, the acting out of the response for the learner with the hope that he or she will imitate it.

Monomorphic A term applied to species in which males and females appear quite similar in certain characteristics such as plumage color. See **dimorphic.**

Monozygotic twins Twins that develop from a single fertilized egg. Called identical twins, 100 percent of their genetic information is shared. See **dizygotic twins.**

Morula In human development, the solid cluster of cells that has formed three days after fertilization.

Motivation An internal state of arousal, resulting from some stimulus, that commonly leads to behavior that is directed toward some goal.

Motoneuron An efferent neuron.

Motor areas Areas of the cerebral cortex that control skeletal muscles.

Multiple personality A dissociative disorder according to DSM III that involves the development of two or more distinct personalities in one individual.

Multi-store model of memory A model of memory that divides memory into separate structures (stores) that differ from one another in terms of their capacity and duration. See **levels-of-processing.**

Mutate A change that occurs in the structure of a gene so that it has a different effect.

Myelin sheath A fatty surface layer that surrounds, protects, and insulates the axons of most neurons.

Naturalistic observation A method of investigating a phenomenon that involves the observation of behavior where it normally occurs.

Natural selection In evolution theory, the idea that those individuals who inherit physical and behavioral traits better suited to the particular environment are more likely to survive and reproduce.

Nature-nurture issue A centuries-old debate about the relative influences of heredity (nature) and environment (nurture) on the behavior of human beings.

Negative reinforcement In instrumental learning, the increase in the strength of a response when that response precedes the removal of an aversive stimulus.

Negative reinforcer In instrumental learning, the aversive stimulus that is removed, contingent upon a response being made.

Negative transfer In problem solving, a phenomenon in which training or experience with one problem inhibits the solution of a different problem.

Neonate A newborn infant.

Nerve A bundle of axons outside the central nervous system.

Neural crests The division of cells along the neural groove in the human embryo that later becomes the majority of the peripheral nervous system.

Neural groove A groove that appears in the human embryo at about 2½ weeks of age where the neural plate has sunk into the dorsal surface.

Neural plate A group of cells on the dorsal surface of the embryo that is the beginning of the nervous system.

Neural reflex arc The basic functional unit in the nervous system: from sensory (afferent) neurons to the central nervous system to motoneurons (efferent) to the appropriate muscle or gland.

Neural tube At five weeks the neural groove in the human embryo closes over, separating from the outer surface and forming a tube. This is the beginning of the central nervous system.

Neuron A nerve cell specialized to transmit information in the form of electrochemical impulses.

Neurosis A behavior disorder characterized by a great deal of anxiety. Inadequate attempts to deal with conflict and fear brought about by stressors in the environment, external or internal.

Neurotransmitter A substance released from the tip of an axon into the synaptic cleft that plays a major role in exciting or inhibiting the firing of adjacent neurons.

Neutral stimulus (NS) In classical conditioning, a stimulus that does not elicit a particular unconditioned response.

Nodes of Ranvier Gaps in the myelin sheath on the axons of neurons.

Noise An irrelevant stimulus.

Normal curve In statistics, the familiar bellshaped distribution that is representative of many naturally occurring characteristics.

Normative group The group used to standardize a test; those individuals who constitute a comparison group for all others who take the test.

NREM (nonREM) sleep Periods of sleep not characterized by rapid eye movements. See **rapid-eye-movement sleep.**

Nucleus (1) A group of neuron cell bodies within the central nervous system; (2)a body within a cell that contains the chromosomes.

Object concept In Piagetian theory, the view that infants develop an awareness between four months and two years of life that people and objects are permanent fixtures in the environment.

Observational learning A subtype of instrumental learning characterized by the acquisition of patterns of behavior from witnessing these patterns in others.

Occipital lobe The posterior portion of the cerebral cortex.

Oedipal conflict In psychoanalytic theory, the conflict of the phallic stage in which a boy perceives a rivalry with his father because of the boy's sexual desire for his mother.

Olfaction Odor detection.

Olfactory epithelium Sensory receptors in a small area of the upper nasal passages that detect odors.

Ontogenetic Developmental.

Operant conditioning Skinner's term for instrumental learning, which suggests that the learner's behavior operates on, or has an effect on, the environment.

Operational definition An objective definition of a phenomenon that lists observable criteria that can be used to identify, record or measure the phenomenon.

Opponent theory of color vision Three paired opposing color systems (white-black, red-green, yellow-blue) that account for the perception of all colors. When cells in each system respond to one color, response to the complementary color is inhibited. See **component theory of color vision.**

Oral stage In psychoanalytic theory, the first stage of psychosexual development (0–1½ years), in which libido is focused on the mouth and oral activities.

Ordinate In statistics, the verticle axis of a graph.

Organization In Piagetian theory the innate tendency to interrelate various schemes, which produces stable cognitive structures.

Organs of Corti Groups of hair cells in the inner ear attached to the basilar membrane and embedded in the tectorial membrane. Displacement of the membranes stimulates the hairs, which stimulate the auditory nerve.

Oval window An opening in the bone of the inner ear. Vibrations hit the oval window twenty times as hard as at the eardrum in order to set in motion the liquid beyond the window.

Overt activities External and easily observed behavior.

Ovulation Release of the ovum from the ovaries once every 28 days in human females.

Ovum The female reproductive cell. See **gamete.**

Ovum, period of In human development, the first two weeks after fertilization, characterized by rapid mitosis and some differentiation.

Oxytocin A hormone from the posterior pituitary that aids in uterine muscle contraction during birth.

Panic disorder An acute and fairly short-lived onset of anxiety, usually lasting one minute to one hour, that involves distressing physical symptoms and apprehension.

Paranoid schizophrenia A form of schizophrenia characterized by delusions of grandeur and persecution sometimes accompanied by hallucinations.

Parasympathetic nervous system One of two parts of the autonomic nervous system which, by acting antagonistically to the sympathetic nervous system, tends to reduce stimulation of organs. The parasympathetic nervous system is more active during quiet, resting states. See **sympathetic nervous system.**

Parietal lobe One of the four lobes of the cerebral hemisphere.

Parsimonious inference An inference that is economical in terms of the level of complexity used to explain the data.

Partial reinforcement schedule (PRF) In instrumental learning, reinforcement of responses in a ratio of less than 1 : 1.

Passive avoidance In instrumental learning, aversive learning in which the subject learns not to make a response that has been followed by an aversive stimulus.

Penis envy In psychoanalytic theory, the belief that young girls direct hostility toward their mothers, because they feel inadequate and cheated for not having a penis.

Percentile rank In statistics, a measure of relative standing that indicates the percentage of scores that fall below a particular score value.

Percept A meaningful impression derived from sensory information.

Peripheral nervous system (PNS) All nervous structures outside the central nervous system.

Persona According to Jung, the outward manifestation of the conscious aspect of personality; a mediator between the personality and the external world.

Personal space The invisible boundary around an individual that others should not enter.

Personal unconscious According to Jung, a part of the unconscious that contains repressed wishes, fantasies, and urges.

Personality The distinctive patterns of behavior (including thoughts and emotions) that characterize each individual's adaptation to the situations of his or her life.

Personality inventory An assessment tool; "paper and pencil" tests consisting of items that describe various personal characteristics.

Phallic stage In psychoanalytic theory, the third stage of psychosexual development (3–5½ years), in which libido is focused on the child's genitals.

Phenomenological investigation An unstructured form of introspection used by Gestalt psychologists to assess perception.

Phenotype A structural, physiological, or behavioral characteristic that is the result of gene action in combination with the effects of environmental factors.

Phenyketonuria (PKU) A developmental disorder that can result in damage to the central nervous system and varying degrees of mental retardation if not treated shortly after birth.

Pheromone A substance secreted by one individual that has a rather profound effect on another individual, usually of the same species. It is typically detected as an odor.

Phobia An intense, irrational fear that is specific to certain aspects of the environment, such as high places, enclosed spaces, water, snakes, and spiders.

Phylogenetic Evolutionary.

Pineal body The anatomical structure in the brain of four-footed animals that is involved in the production of melatonin, which is important in influencing rhythmic activities related to changing day lengths.

Pinna The visible part of the ear that includes the flap of skin and cartilage.

Pituitary gland The gland located at the base of the brain that produces hormones important in the regulation of other glands in the endocrine system.

Placebo effect A change in behavior that results from the expectation of the effect of an experimental condition (e.g., expecting a particular drug), rather than from the condition (e.g., actual drug) itself.

Placenta In human development, the organ that provides nutrients from mother to embryo and removes waste materials.

Polygenic traits Traits that are controlled by more than one gene pair.

Polygynous The mating of one male to more than one female.

Pons The portion of the brain between the medulla and the midbrain; it is a major control center for facial expression, feeding, hearing, and balance.

Population In statistics, the entire group of possible subjects or cases from which the researcher will draw a sample; (2) in ecological-evolutionary usage, all the members of a species in a given area.

Positive reinforcement In instrumental learning, the increase in response strength that occurs when a rewarding stimulus follows a response.

Positive reinforcer In instrumental learning, the stimulus that follows a response and thereby increases the likelihood the response will occur again.

Positive transfer In problem solving, a phenomenon in which learning to solve one problem facilitates the solution of a different problem.

Posterior The tail end; also called caudal.

Postsynaptic membrane A portion of the cell membrane at the tip of the dendrite of the receiving neuron.

Precocial birds Active birds that are able to move about freely upon hatching. See **altricial.**

Preconscious In psychoanalytic theory, the part of the mind containing information that may be temporarily forgotten but which can be recalled. See **conscious; unconscious.**

Prefrontal lobotomy A highly controversial psychosurgical treatment for severe psychological disorders in which the fibers that connect the frontal lobes of the cerebrum to the thalamus are severed.

Preoperational stage In Piagetian theory, the second stage of cognitive development (2–7 years), characterized by the acquisition of signifiers and the development of intuitive reasoning.

Presynaptic membrane A portion of the cell membrane at the tip of the synaptic knob.

Primacy effect A memory phenomenon in which the first items presented in a list are more likely to be remembered than items in the middle of the list; part of the serial position effect. See **recency effect.**

Primary sexual characteristics Ovulation and menstruation, growth of vagina, clitoris, and uterus in females; production of sperm, growth of testes and penis in males. See **secondary sexual characteristics.**

Primate One of an order of mammals that includes humans, apes, and monkeys.

Proactive interference Interference in retaining a memory from events that precede the presentation of the items to be remembered. See **retroactive interference.**

Progesterone A female sex hormone.

Projection In Freudian psychoanalytic theory, the ego defense mechanism in which the individual ascribes undesirable internal motives or dispositions to others. See **ego defense mechanisms.**

Projective test An assessment tool that consists of relatively unstructured, ambiguous items that the examinee interprets; the tests are designed to elicit projection in which unconscious conflicts may be revealed.

Prolactin A hormone secreted by the anterior pituitary that promotes growth of female breasts during adolescence and secretion of milk following pregnancy.

Prompting In instrumental learning, leading the learner through the mechanisms of the response, or providing a cue for the response.

Prosocial behavior Behavior associated with giving and receiving benefits; cooperative, helpful, sharing behavior.

Prostaglandin A hormone produced in the pregnant uterus that aids uterine muscle contraction during birth.

Proximity A Gestalt principle of perceptual organization: those elements in a figure nearest to one another tend to be perceived as belonging to a group.

Proximodistal principle The principle that development proceeds from the center of the body to the periphery.

Psychiatry The area of medicine specializing in the understanding and treatment of psychological disorders.

Psychoanalysis The therapy based on Sigmund Freud's psychoanalytic threory.

Psychoanalytic theory The approach to psychology identified with Sigmund Freud that is based on the belief that behavior is determined by the interplay of pleasure-seeking (sexual impulses) and inhibitory processes, much of which operates at an unconscious level of awareness.

Psychogenic amnesia A dissociative disorder according to DSM III that involves a loss of memory, especially memory for personal experiences and identity.

Psychology The scientific study of behavior.

Psychopathology Emotional disturbance.

Psychophysics The scientific study of the relation between physical stimuli and the sensory experiences they produce.

Psychosis A serious psychological disturbance that is marked by a loss of touch with reality. Examples include major affective disorders and schizophrenia.

Punishment In instrumental learning, the process of following a response with an aversive stimulus, which lowers the probability of that response occurring again.

Purkinje cells A group of neurons in the cerebellum that have a regulatory effect and help the cerebellum moderate and tune motor activity.

Random search Strategies that involve trial-and-error attempts to solve problems. See **heuristic search strategies.**

Range In statistics, a measure of variability obtained by subtracting the lowest score from the highest in a distribution.

Rapid-eye-movement sleep (REM) A state of sleep characterized by rapid eye movement under closed eyelids that is associated with dreaming in adults.

Rational-emotive therapy A cognitive therapy that attempts to change a person's irrational beliefs.

Rationalization In Freudian psychoanalytic theory, the ego defense mechanism that involves supplying reasons and justifications for taking a particular course of action or for failing to accomplish some goal. See **ego defense mechanisms.**

Recall Production of an item from memory. (compare: recognition)

Recency effect A memory phenomenon in which the last items presented in a list are more likely to be remembered than items presented in the middle of the list; part of the serial position effect. See **primacy effect.**

Receptor A receiver; an afferent nerve ending or a cell in a sense organ that is in contact with an afferent nerve.

Recessive An allele that expresses itself (causes the appearance in the phenotype of the characteristic it influences) only when pure.

Reciprocal altruism The idea that we are inclined to help nonrelatives because doing so has, in our evolutionary past, increased the fitness of the helper. The nonrelatives presumably lived nearby and thus were in a position to return the favor.

Recognition Identification of an item as one that has (or has not) been previously stored in memory.

Reflex An innate, relatively simple and automatic response to a specific stimulus, such as the sucking reflex in neonates. See **instinct.**

Refractory period A brief period of time during which a section of nerve fiber cannot conduct an impulse, or can do so only when higher-than-threshold levels of stimulation are applied.

Rehearsal A strategy for retaining information in short-term memory and transferring information to long-term memory.

Relative refractory period The second part of the refractory period during which the threshold for firing is a bit higher than normal. See **absolute refractory period.**

Relevant variables In an experiment, factors held constant (controlled) by the researcher because they have the potential to influence the dependent variable.

Reliability The characteristic of a good test (or test item) that it produces consistent results. See **Validity.**

Renin A hormone secreted into the bloodstream by the kidneys to stimulate thirst when the body is short of liquids.

Response frequency In instrumental learning, the number of errors (or correct responses) made in a problem-solving situation.

Response latency In instrumental learning, the time it takes a learner to make a correct response once a particular stimulus has been presented.

Response rate In instrumental learning, the number of correct responses a learner makes relative to a specific time period.

Reticular formation The core of the brainstem that integrates a variety of information and is involved in swallowing, vomiting, respiration, cardiovascular functions, and sleeping and waking.

Retina The light-sensitive membrane containing the visual receptors at the back of each eye.

Retinal disparity A binocular cue to depth that results from the slightly different images cast on each retina.

Retroactive interference Interference in retaining a memory from events that follow the presentation of the items to be remembered. See **proactive interference.**

Reversibility In Piagetian theory, the ability to mentally reverse, or undo, an event; achieved during the stage of concrete operations.

Rod One of the photoreceptive cells located on the retina of the eye that converts light energy into nerve impulses sensitive to faint light but not to color. See **cone.**

Rorschach test A projective test consisting of ten inkblots that the examinee interprets.

Saccades Tiny, rapid movements of the eyes that are involuntary and normally occur during visual scanning (as in reading) or fixation (as in staring at an object).

Sample In statistics, a subset of a population.

Saturation The perceived "richness" of a hue; the purity of a color where purity means that little or no white light is mixed with a monochromatic wave length. See **brightness; hue.**

Scatterplot In statistics, a graph indicating pairs of X Y values.

Scheme In Piagetian theory, an individual concept or behavior.

Schizophrenia A serious psychological disorder according to DSM III characterized by disturbances in language and thought, perception, motor behavior, affect, and/or social behavior.

Scientific method An approach to the study of phenomena that relies upon objective observation as a means of attaining knowledge.

Scramble competition A form of competition in which resources are sought without particular regard for competitors. See **contest competition.**

Secondary reinforcement In instrumental learning, the idea that because discriminative stimuli have become associated with reinforcement of a particular behavior, they can be used to reinforce that behavior or possibly others. See **higher-order conditioning.**

Secondary sexual characteristics Facial hair, deepened voice, broadening shoulders in males; development of breasts and hips in females; pubic hair in both sexes. See **primary sexual characteristics.**

Selection pressure Some condition in the environment that favors one characteristic over another, or favors a particular type of genetic change if it should occur.

Self-actualization In humanistic theories of personality the tendency to develop one's potentials in ways that maintain or enhance the organism.

Semantic memory Memory in the long-term store, consisting of symbols and meanings for things. See **episodic memory.**

Semicircular canals Three structures of the inner ear, each lying in a different plane, that detect movement of the head in any direction.

Semiotic function In Piagetian theory, the acquisition of signifiers, an understanding of what they are, and an ability to use signifiers, which is accomplished during the preoperational stage.

Sensitive period A period of rapid development of behavior systems, during which those systems may require certain environmental inputs for optimal development and are highly sensitive to these and other environmental influences. See **critical period.**

Sensorimotor stage In Piagetian theory, the first stage of cognitive development (0–2 years), characterized by attainment of the object concept.

Sensory areas Areas of the cerebral cortex that receive data from sense organs.

Sensory register The first memory structure in the multi-store model of memory; a memory store in which information is held in its original, unprocessed state for less than one second, or at most, very few seconds. See **long-term; short-term memory.**

Septal area A portion of the brain that produces a pleasure-like state when stimulated.

Serial position effect A memory phenomenon in which individuals recall the initial items and the last items of a list much better than those items in the middle of the list. See **primacy effect; recency effect.**

Shaping In instrumental learning, the reinforcement of successive approximations of the desired response.

Short-term memory The second memory structure in the multi-store model of memory; a store with adult capacity of about 5 to 9 chunks of information with a duration of about 30 seconds. See **long-term memory; sensory register.**

Sibling Brother or sister.

Sign In Piagetian theory, a mental representation of an object or event that is abstract, such as a word. See **symbol.**

Signal detection theory The theory which states that for a particular sensory system, the absolute threshold varies from individual to individual, and for a single individual it varies at different times; distinguishes between sensory and nonsensory factors that can affect detection of a stimulus.

Signifier In Piagetian theory, objects, images, words, or thoughts that stand for other things; signs and symbols.

Similarity A Gestalt principle of perceptual organization: elements that look alike in a figure tend to be perceived as belonging to a group.

Single-blind technique A way to control for bias in an experiment by keeping the subject uninformed about the particular treatment that the experimenter will administer. See **double-blind technique.**

Size constancy The tendency to perceive a familiar object as relatively constant in size even though the size of the retinal image changes as the object moves closer or farther away.

Skewed distribution In statistics, a nonnormal distribution in which most of the scores lie below the mean (positive skew) or above the mean (negative skew).

Sociability According to Eysenck, a genetically-based dimension of personality reflected in behavior on an introversion to extroversion continuum.

Social behavior All behavior that is related to actual or potential encounters between individuals.

Social exchange theory A theory based on the idea that people weigh the costs and benefits, sometimes unconsciously, when deciding to enter into or continue a social transaction.

Social facilitation The stimulation of an activity, or the improvement of performance, due to the presence of others.

Socialization The process by which an individual acquires information that is useful or necessary for getting along in a particular social group or culture.

Social psychology The area of specialization within psychology that is concerned with interactions and relationships among people.

Sociobiology The scientific study of biological bases of social behavior, especially the adaptive significance and evolutionary history of social behavior.

Somatic components The part of the peripheral nervous system involved in transmitting information from sensory structures and in controlling skeletal muscles.

Somatoform disorders A category of psychological disorders according to DSM III that involves physical symptoms in the absence of any known organic pathology.

Somatotropic hormone (STH) A growth hormone produced by the anterior pituitary. Too much of the hormone produces giants; too little, midgets.

Somatotype theory A theory of personality based on a presumed relation between body type (endomorphy, ectomorphy, mesomorphy) and temperament.

Spatial summation Excitatory or inhibitory effects produced in the various dendrites of a neuron, added together to determine whether the neuron will conduct an impulse.

Species A group of (actually or potentially) interbreeding individuals who do not breed with members of other such groups under natural conditions.

Sperm The male reproductive cell. See **gamete.**

Spinal cord The collection of nerve fibers in the spinal column that connect the brain to receptors throughout the body.

Spontaneous recovery In classical conditioning, the reappearance of the conditioned response (CR) during extinction even though no pairing of the unconditioned stimulus (UCS) and conditioned stimulus (CS) has occurred.

Standard deviation In statistics, a measure of variability. It is the square root of the variance.

Stapes One of the small bones of the middle ear called the stirrup. See **auditory ossicles.**

State-dependent memory The idea that memory retrieval is better when the physical state of the individual at the time of retrieval matches that when the information was first acquired.

Statistics Numbers that summarize a phenomenon; the technical branch of mathematics concerned with describing and analyzing data.

Status One's position in the dominance hierarchy of a group.

Stevens' Power Law The observation that the intensity of sensation perceived is equal to the magnitude of the stimulus raised to some power and multiplied by a constant: $S = KR^N$.

Stimulus Anything in the environment that has the potential to evoke a response.

Stimulus generalization (1) In classical conditioning, the tendency for stimuli that are similar to the conditioned stimulus (CS) to elicit the conditioned response (CR). A similar process occurs in instrumental learning. (2) In habituation, a lower than normal level of response to a stimulus encountered only once, but which resembles a stimulus habituated to previously.

Stimulus-response concept The basic idea of behaviorism that behavioral responses can be analyzed according to the external environmental stimuli that elicit them.

Stranger anxiety Fear associated with unfamiliar adults that occurs in some infants between six months and fifteen months.

Structural Anatomical.

Structuralism The approach to psychology in which the constituent elements of conscious experience were analyzed; the structure of consciousness was emphasized over its functions. See **functionalism.**

Superego In psychoanalytic theory, a component of personality that is an internalized code of morality capable of exerting control over behavior. See **ego; id.**

Superior colliculi A pair of small swellings in the midbrain of mammals, that contain important relay nuclei for the visual system.

Symbol In Piagetian theory, a mental representation that is concrete and directly resembles the object it represents. See **sign.**

Sympathetic nervous system One of two parts of the autonomic nervous system, which, by acting antagonistically to the parasympathetic nervous system, tends to stimulate organs. The sympathic nervous system is more active during arousal and stress. See **parasympathetic nervous system.**

Synapse The functional connection between neurons consisting of a portion of cell membrane at the tip of an axon, a space, and a portion of cell membrance of a dendrite.

Synaptic cleft The space between the axon knob of one neuron and the dendrite of the next.

Synaptic knob The swelling at each axon branch tip.

Synaptic vesicle The sac within each synaptic knob that contains neurotransmitter.

Systematic desensitization A behavior therapy in which a feared stimulus is introduced gradually during periods of deep muscle relaxation.

Tabula rasa Literally, blank slate; John Locke's idea that human behavior is totally learned, and thus not at all influenced by genetics.

Tactile The sense of touch.

Tapetum A pigment layer in the retina of many nocturnal animals that reflects light to the light-sensitive cells and thus increases the amount of light received by the cells.

Telegraphic speech A child's first two-word speech combinations, which occur between 18 months and two years.

Telencephalon The largest part of the brain, which includes the limbic system and cerebrum.

Temporal contiguity The state of temporal proximity between events; in classical conditioning, the requirement that the neutral stimulus (NS) and unconditioned stimulus (UCS) must occur close together in time in order for learning to occur.

Temporal lobe One of the four sections of the cerebral cortex.

Temporal summation The effects of rapidly repeated impulses in an axon added together in determining whether a receiving neuron will conduct an impulse.

Teratogen In human development, an environmental factor that is associated with embryonic or fetal mortality or developmental disabilities.

Testosterone The primary male sex hormone.

Texture gradient A monocular cue to depth. Surfaces that are nearer tend to be more detailed in terms of contour, contrast, and complexity than surfaces farther away.

Thalamus A part of the diencephalon that receives and relays sensory information regarding taste, touch, vision, hearing, and pain.

Thanatos In psychoanalytic theory, the category of instincts that includes the death wish. See **Eros.**

Thematic Apperception Test (TAT) A projective test consisting of 30 pictures of people in ambiguous situations and one blank picture, each of which the examinee interprets; designed to reveal unconscious personality characteristics.

Theory A scientific explanation of observed phenomena.

Threshold The level of stimulation at which an effect or response is produced.

Thyroxin A hormone secreted by the thyroid gland. A deficiency of thyroxin in infants retards growth and can lead to mental retardation.

Token economy A group behavior therapy or management program emphasizing positive reinforcement; appropriate behavior is rewarded with agreed upon signifiers—tokens—that can be exchanged for more tangible rewards.

Trace decay theory of forgetting The theory that information is lost from memory stores because of the passage of time.

Tract A bundle of axons in the central nervous system.

Transduction The transformation of stimuli into neural impulses.

Transference In psychoanalytic theory, the development by the patient of strong positive or negative feelings toward the therapist. See **countertransference.**

Transsexualism A condition in which a person feels trapped in a body of the wrong sex.

Trephining The practice in early human societies of cutting a hole in the skull, presumably to release demons or spirits responsible for abnormal behavior.

Two-factor theory of intelligence Spearman's theory that intellectual performance consists of an innate general factor (g-factor) and specific factors (s-factors).

Umbilical cord In human development, a cord-like structure containing blood vessels that carry blood between the embryo and the walls of the placenta.

Unconditioned response (UCR) In classical conditioning, an unlearned, automatic response to a specific stimulus; a reflex.

Unconditioned stimulus (UCS) In classical conditioning, the stimulus that ordinarily elicits a reflex.

Unconscious In psychoanalytic theory, the part of the mind that contains id impulses. See **conscious; preconscious.**

Unlearned Innate.

Validity The characteristic of a good test (or test item) that it measures what it is designed to measure.

Variable In statistics, a quantity that may take on more than one value.

Variable-interval (VI) schedule of reinforcement In instrumental learning, reinforcement that occurs after the first correct response following the passage of varying amounts of time.

Variable-ratio (VR) schedule of reinforcement In instrumental learning, reinforcement that occurs after varying numbers of responses.

Variance In statistics, a measure of variability that reflects a sort of average amount of difference between each score and the mean in a given distribution.

Variety A group of plants or animals recently descended from ancestors common to other varieties, so that while varieties are distinguishable, they are sufficiently similar to be able to interbreed freely and successfully.

Ventral The belly side or underside.

Ventromedial hypothalamus (VMH) The lower middle part of the hypothalamus. When this inhibitory or satiety center is stimulated, test animals will reduce or stop eating. See **lateral hypothalamus.**

Vertebrates Animals having a vertebral column (backbone).

Vestibular sacs Structures of the inner ear. Hair cells in the vestibular sacs detect the position of the head.

Vicarious punishment Observed punishment of the behavior of a model that decreases the likelihood of imitation by the observer.

Vicarious reinforcement Observed reinforcement of the behavior of a model that increases the likelihood of imitation by the observer.

Visceral components The part of the peripheral nervous system involved with transmitting information from and to smooth muscles, cardiac muscle, and glands.

Visual acuity Sharpness and clarity of vision.

Weber's Law The observation that the intensity of a stimulus must be changed by a certain percentage before it can be perceived as different: $\frac{R}{R} = K$.

See **just noticeable difference.**

Wernicke's area The language area of the brain that controls speech comprehension. See **Broca's area.**

Within-subjects design An experimental design in which the researcher compares the same subjects under each condition of the independent variable. See **between-subjects design.**

Zygote The fertilized ovum.

Bibliography

Adams, J. S. (1963). Toward an understanding of inequity. *Journal of Abnormal and Social Psychology, 67,* 422–436.

Adolph, E. F. (1941). The internal environment and behavior: Water content. *American Journal of Psychiatry, 97,* 1365–1373.

Aiden, L. R. (1979). *Psychological testing and assessment.* Boston: Allyn & Bacon.

Ainsworth, M. D. S. (1967). *Infancy in Uganda: Infant care and the growth of love.* Baltimore: Johns Hopkins University Press.

Aitchison, J. (1976). *The articulate mammal: An introduction to psycholinguistics.* New York: Universe Books.

Alcock, J. (1975). *Animal behavior: An evolutionary approach.* Sunderland, MA: Sinauer.

———. (1979). *Animal behavior: An evolutionary approach* (2nd. ed.). Sunderland, MA: Sinauer.

Alexander, R. D. (1971). The search for an evolutionary philosophy of man. *Royal Society of Victoria, Proceedings, 84*(1), 99–119.

———. (1975). The search for a general theory of behavior. *Behavioral Science, 20,* 77–100.

Alland, A., Jr. (1973). *Evolution and human behavior.* Garden City, NY: Anchor Press/Doubleday.

Anand, B. K., Sharma, K. W., & Dua, S. (1964). Activity of single neurons in the hypothalamic feeding centers: Effect of glucose. *American Journal of Physiology, 207,* 1146–1154.

Anders, T. R., & Fozard, J. L. (1973). Effects of age upon retrieval from primary and secondary memory. *Developmental Psychology, 9,* 411–416.

Anderson, R., & Nida, S. A. (1978). Effect of physical attractiveness on opposite- and same-sex evaluations. *Journal of Personality, 46,* 401–413.

Andrew, R. J., & Brennan, A. (1983). The lateralization of fear behavior in the male domestic chick: A developmental study. *Animal Behavior, 31,* 1166–1176.

Annett, M. (1959). The classification of instances of four common class concepts by children and adults. *British Journal of Educational Psychology, 29,* 223–236.

Aronson, E. (1976). *The social animal.* San Francisco: Freeman.

Asch, S. E. (1951). Effects of group pressure upon the modification and distortion of judgments. In H. Guetzkow (Ed.), *Groups, leadership, and men.* Pittsburgh: Carnegie Press.

Aschoff, J. (1969). Desynchronization and resynchronization of human circadian rhythms. *Aerospace Medicine, 40,* 844–849.

——— (Ed.). (1981). *Handbook of behavioral neurobiology.* Vol. 4, *Biological rhythms.* New York: Plenum.

Aserinsky, E., & Kleitman, N. (1953). Regularly occurring periods of eye motility, and concomitant phenomena during sleep. *Science, 118,* 272–274.

Aslin, R. N., Pisoni, D. P., & Jusczyk, P. W. (1983). Auditory development and speech perception in infancy. In M. M. Haith & J. J. Campos (Eds.), *Handbook of child psychology: Infancy and developmental biology.* New York: Wiley.

Averbach, E., & Sperling, G. (1961). Short-term storage of information in vision. In C. Cherry (Ed.), *Fourth London symposium on information theory.* London and Washington, D.C.: Butterworth.

Avery, D., & Winokur, G. (1977). The efficacy of electroconvulsive therapy and antidepressants in depression. *Biological Psychiatry, 12,* 507–523.

Azrin, N. H., & Foxx, R. M. (1971). A rapid method of toilet training the institutionalized retarded. *Journal of Applied Behavior Analysis, 4,* 89–99.

Baddeley, A. D. (1978). The trouble with levels: A reexamination of Craik and Lockhart's framework for memory research. *Psychological Review, 85,* 139–152.

Baddeley, A. D., & Hitch, G. J. (1977). Recency re-examined. In S. Dornic (Ed.), *Attention and Performance: VI.* Hillsdale, NJ: Lawrence Erlbaum.

Balling, J. D., & Falk, J. H. (1982). Development of visual preference for natural environments. *Environment & Behavior, 14,* 5–28.

Bandura, A. (1965). Influence of models' reinforcement contingencies on the acquisition of imitative responses. *Journal of Personality and Social Psychology, 1,* 589–595.

———. (1973). *Aggression: A social learning analysis.* Englewood Cliffs, NJ: Prentice-Hall.

———. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice-Hall.

———. (1979). Psychological mechanisms of aggression. In M. von Cranach, K. Foppa, W. Lepenies, & D. Ploog (Eds.), *Human ethology.* Cambridge: Cambridge University Press.

Bandura, A., Ross, D., & Ross, S. (1961). Transmission of aggression through imitation of aggressive models. *Journal of Abnormal and Social Psychology, 63,* 375–382.

———. (1963a). Imitation of film-mediated aggressive models. *Journal of Abnormal and Social Psychology, 66,* 3–11.

———. (1963b). Vicarious reinforcement and imitative learning. *Journal of Abnormal and Social Psychology, 67,* 601–607.

Bandura, A., & Walters, R. H. (1959). *Adolescent aggression.* New York: Ronald.

Banks, M. S., & Salapatek, P. (1983). Infant visual perception. In M. M. Haith & J. J. Campos (Eds.), *Handbook of child psychology: Infancy and developmental biology.* New York: Wiley.

Baptista, L. F., & Petrinovich, L. (1984). Social interaction, sensitive phases and the song template hypothesis of the white-crowned sparrow. *Animal Behavior, 32,* 172–181.

Barash, D. P. (1976). The male response to apparent female adultery in the mountain bluebird, *Sialia currucoides:* An evolutionary interpretation. *American Naturalist, 110,* 1097–1101.

———. (1977). *Sociobiology and behavior.* New York: Elsevier.

———. (1982). *Sociobiology and behavior* (2nd ed.). New York: Elsevier.

Barbizet, C. J. (1970). *Human memory and its pathology.* Philadelphia: Lippincott.

Bard, P. (1928). A diencephalic mechanism for the expression of rage with special reference to the sympathetic nervous system. *American Journal of Physiology, 84,* 490–515.

Barkow. J. H. (1983). Begged questions in behavior and evolution. In G. C. L. Davey (Ed.), *Animal models of human behavior.* Chichester, England: Wiley.

Baron, R. A. (1977). *Human aggression.* New York: Plenum.

Barron, F. (1969). *Creative person and creative process.* New York: Holt, Rinehart and Winston.

Baum, A., & Valins, S. (1977). *Architecture and social behavior: Psychological studies in social density.* Hillsdale, NJ: Lawrence Erlbaum.

Bayley, N. (1933). *The California first-year mental scale.* Berkeley: University of California Press.

———. (1949). Consistency and variability in the growth of intelligence from birth to eighteen years. *Journal of Genetic Psychology, 75,* 165–196.

———. (1955). On the growth of intelligence. *American Psychologist, 10,* 805–818.

Beach, F. A., & Ransom, T. W. (1967). Effects of environmental variation on ejaculatory frequency in male rats. *Journal of Comparative and Physiological Psychology, 64,* 384–387.

Beck, A. T. (1967). *Depression: Clinical, experimental, and theoretical aspects.* New York: Harper & Row.

———. (1976). *Cognitive therapy and the emotional disorders.* New York: International Universities Press.

Bem, D. J., & Allen, A. (1974). On predicting some of the people some of the time: The search for cross-situational consistencies in behavior. *Psychological Review, 81,* 506–520.

Benton, D. (1983). Do animal studies tell us anything about the relationship between testosterone and human aggression? In G. L. C. Davey (Ed.), *Animal models of human behavior.* Chichester, England: Wiley.

Berger, R. J. (1961). Tonus of extrinsic laryngeal muscles during sleep and dreaming. *Science,* 134, 840.

Berger, T. W., Alger, B., & Thompson, R. F. (1976). Neuronal substrate of classical conditioning in the hippocampus. *Science, 192,* 483–485.

Bergin, A. E. (1971). The evaluation of therapeutic outcomes. In A. E. Bergin & S. L. Garfield (Eds.), *Handbook of psychotherapy and behavior change: An empirical analysis.* New York: Wiley.

Bergin, A. E., & Lambert, M. J. (1978). The evaluation of therapeutic outcomes. In S. L. Garfield & A. E. Bergin (Eds.), *Handbook of psychotherapy and behavior change: An empirical analysis (2nd. ed.)* New York: Wiley.

Berkowitz, L. (1957). Effects of perceived dependency relationships upon conformity to group expectations. *Journal of Abnormal and Social Psychology, 55,* 350–354.

———. (1969). The frustration-aggression hypothesis revisited. In L. Berkowitz (Ed.), *Roots of aggression.* New York: Atherton.

———. (1972). Social norms, feelings, and other factors affecting helping and altruism. In L. Berkowitz (Ed.), *Advances in experimental social psychology,* vol. 6. New York: Academic Press.

Berkowitz, L., & Daniels, L. R. (1963). Responsibility and dependency. *Journal of Abnormal and Social Psychology, 66,* 429–437.

Berkowitz, L., Klanderman, S. B., & Harris, R. (1964). Effects of experimenter awareness and sex of subject and experimenter as reactions to dependency relationships. *Sociometry, 27,* 327–357.

Berlin, B., & Kay, P. (1969). *Basic color terms: Their universality and evolution.* Berkeley: University of California Press.

Bermant, G., Lott, D. F., & Anderson, L. (1968). Temporal characteristics of the Coolidge effect in male rat copulatory behavior. *Journal of Comparative and Physiological Psychology, 65,* 447–452.

Bernstein, I. (1978). Learned taste aversions in children receiving chemotherapy. *Science, 200,* 1302–1303.

Bexton, W. H., Heron, W., & Scott, T. H. (1954). Effects of decreased variation in the sensory environment. *Canadian Journal of Psychology, 8,* 70–76.

Blake, J., & Vingilis, E. (1977). Developmental changes in the temporal course of tachistoscopic recognition. *Developmental Psychology, 13,* 39–46.

Blakemore, C. (1974). Developmental factors in the formation of feature extracting neurons. In F. O. Schmitt & F. G. Worden (Eds.), *The neurosciences, third study program.* Cambridge: M.I.T. Press.

Block, N. J., & Dworkin, G. (Eds.). (1976). *The IQ controversy: Critical readings.* New York: Pantheon Books.

Blough, D. S. (1959). Delayed matching in the pigeon. *Journal of the Experimental Analysis of Behavior, 2,* 151–160.

Boesch, E. E., Baltes, P. B., & Schmidt, L. R. (1968). Preferences for different auditory presentation sequences in various age groups. *Psychonomic Science, 10,* 205–206.

Bolles, R. C. (1975a). *Learning theory.* New York: Holt, Rinehart and Winston.

———. (1975b). *Theory of motivation.* New York: Harper & Row.

Bolles, R. C., & Fanselow, M. S. (1982). Endorphins and behavior. *Annual Review of Psychology, 33,* 87–101.

Borke, H. (1975). Piaget's mountains revisited: Changes in the egocentric landscape. *Developmental Psychology, 11,* 240–243.

Bourne, L. E., Dominowsky, R. L., & Loftus, E. F. (1979). *Cognitive processes.* Englewood Cliffs, NJ: Prentice-Hall.

Bower, G. H. (1981). Mood and memory. *Psychology Today, 15,* 60–69.

Bower, G. H., & Winzenz, D. (1970). Comparison of associative learning strategies. *Psychonomic Science, 20* (2), 119–120.

Bower, T. R. G. (1964). Discrimination of depth in premotor infants. *Psychonomic Science,* 1, 368.

———. (1965). Stimulus variables determining space perception in infants. *Science, 149,* 88–89.

———. (1966). The visual world of infants. *Scientific American, 215,* 80–92.

———. (1982). *Development in infancy.* San Francisco: Freeman.

Bower, T. G. R., Broughton, J. M., & Moore, M. K. (1970). Infant responses to approaching objects: An indicator of response to distal variables. *Perception & Psychophysics, 9,* 193–196.

Bowlby, J. (1958). The nature of the child's tie to his mother. *International Journal of Psychoanalysis, 39,* 1–24.

———. (1969). *Attachment and loss. Vol. 1: Attachment.* New York: Basic Books.

———. (1973). *Attachment and loss. Vol. 2: Separation, anxiety and anger.* London: Hogarth.

Brace, C. L. (1967). *The stages of human evolution.* Englewood Cliffs, NJ: Prentice-Hall.

Brainerd, C. J. (1978). *Piaget's theory of intelligence.* Englewood Cliffs, NJ: Prentice-Hall.

Brazelton, T. B. (1973). *Neonatal behavioral assessment scale.* London: Heinemann Medical Books.

Brehm, J. W., & Cohen, A. R. (1962). *Explorations in cognitive dissonance.* New York: Wiley.

Breland, K., & Breland, M. A. (1951). A field of applied animal psychology. *American Psychologist, 6,* 202–204.

———. (1961). The misbehavior of organisms. *American Psychologist, 16,* 681–684.

Bridger, W. H., & Birns, B. (1968). Experience and temperament in human neonates. In G. Newton & S. Levine (Eds), *Early experience and behavior.* Springfield, IL: Thomas.

Bridges, K. M. B. (1932). Emotional development in early infancy. *Child Development, 3,* 324–341.

Bromberg, W. (1975). *From shaman to psychotherapist: A history of the treatment of mental illness.* Chicago: Henry Regnery.

Brosset, A. (1971). L' "imprinting," chez les Colombidés—étude des modifications comportementales au cours de vieillissement. *Z. Tierpsychol., 29,* 279–300.

Brower, L. P. (1969). Ecological chemistry. *Scientific American, 220,* 22–29.

Brower, L. P., & Brower, J. van Z. (1962). Investigations into mimicry. *Natural History, 71,* 8–19.

Brown, A. L., Campione, J. C., & Murphy, M. D. (1974). Keeping track of changing variables: Long-term retention of a trained rehearsal strategy by retarded adolescents. *American Journal of Mental Deficiency, 78,* 446–453.

Brown, J. L. (1975). *The evolution of behavior.* New York: Norton.

Brown, P. L., & Jenkins, H. M. (1968). Autoshaping of the pigeon's key-peck. *Journal of the Experimental Analysis of Behavior, 11,* 1–8.

Brown, R. (1973). *A first language: The early stages.* Cambridge: Harvard University Press.

Brown, R., Cazden, C., & Bellugi, U. (1969). The child's grammar from I to III. In J. P. Hill (Ed.), *Minnesota symposium on child psychology,* vol. 2. Minneapolis: University of Minnesota Press.

Brown, R. M. (1977). An examination of visual and verbal coding processes in preschool children. *Child Development, 48,* 38–45.

Brown, R. M., Brown, N. L., & Caci, M. (1981). Serial position effects in young children: Temporal or spatial? *Child Development, 52,* 1191–1201.

Brown, R. W., & McNeil, D. (1966). The "tip of the tongue" phenomenon. *Journal of Verbal Learning and Verbal Behavior, 5,* 325–337.

Bruce, D. (1985). The how and why of ecological memory. *Journal of Experimental Psychology: General, 114,* 78-90.

Bruner, J. S. (1964). The course of cognitive growth. *American Psychologist, 19,* 1–15.

Bruner, J. S., Olver, R. R., & Greenfield, P. M. (1966). *Studies in cognitive growth.* New York: Wiley.

Bryan, J. H., & Scwartz, T. H. (1971). The effects of film material upon children's behavior. *Psychological Bulletin, 75,* 50-59.

Bryant, P. E. (1974). *Perception and understanding in young children.* New York: Basic Books.

Bunney, W. E., Goodwin, F. K., & Murphy, D. L. (1972). The "switch process" in manic-depressive illness. *Archives of General Psychiatry, 27,* 312–317.

Buscaglia, L. (1972). *Love.* New York: Ballantine Books.

Buss, A. H., Plomin, R., & Willerman, L. (1973). The inheritance of temperaments. *Journal of Personality, 41,* 513–524.

Cairns, R. B. (1979). *Social development: The origins and plasticity of interchanges.* San Francisco: Freeman.

Calhoun, J. B. (1962). Population density and social pathology. *Scientific American, 206,* 139–148.

Calhoun, J. F. (1977). *Abnormal psychology: Current perspectives* (2nd ed.) New York: CRM/Random House.

Campbell, B. A., & Coulter, X. (1976). The ontogeny of learning and memory. In M. R. Rosenzweig & L. Bennett (Eds.), *Neural mechanisms of learning and memory.* Cambridge: M.I.T. Press.

Campbell, D. T. (1975). On the conflicts between biological and social evolution and between psychology and moral tradition. *American Psychologist, 30,* 1103–1126.

Campos, J. J., Langer, A., & Krowitz, A. (1970). Cardiac responses on the visual cliff in prelocomotor human infants. *Science, 170,* 196–197.

Cannon, W. B. (1927). The James Lange theory of emotions: A critical examination and an alternative theory. *American Journal of Psychology, 39,* 106–124.

Carlson, N. R. (1981). *Physiology of Behavior* (2nd ed.). Boston: Allyn & Bacon.

Cattell, J. M. (1890). Mental tests and measurements. *Mind, 15,* 373–381.

Cattell, P. (1940). *The measurement of intelligence of infants and young children.* New York: Science Press.

Cautela, J. R. (1966). Treatment of compulsive behavior by covert sensitization. *Psychological Record, 16,* 33–41.

Cavanaugh, J. C., & Perlmutter, M. (1982). Metamemory: A critical examination. *Child Development, 53,* 11–28.

Charlesworth, W. R. (1976). Human intelligence as adaptation: An ethological approach. In L. B. Resnick (Ed.), *The nature of intelligence.* Hillsdale, NJ: Lawrence Erlbaum.

Chi, M. T. H. (1976). Short-term memory limitations in children: Capacity or processing deficits? *Memory & Cognition, 4,* 559–572.

Chomsky, N. (1975). *Reflections on language.* New York: Pantheon.

Christian, J. J., Flyger, V., & Davis, D. C. (1960). Factors in the mass mortality of a herd of Sika deer, *Cervus nippon. Chesapeake Science, 1,* 79–95.

Clark, H. H., & Clark, E. V. (1977). *Psychology and language: An introduction to psycholinguistics.* New York: Harcourt Brace Jovanovich.

Clark, R. B. (1960). Habituation of the polychaete Nereis to sudden stimuli: 1. General properties of the habituation process. *Animal Behavior, 8,* 82–91.

Coleman, J. C. (1976). *Abnormal psychology and modern life (5th ed.).* Glenview, IL: Scott Foresman.

Coleman, J. C., Butcher, J. N., & Carson, R. C. (1984). *Abnormal psychology and modern life* (7th ed.). New York: Scott, Foresman.

Collins, A. M., & Quillian, M. R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior, 8,* 240–247.

Condon, W. S., & Sander, L. W. (1974). Neonate movement is synchronized with adult speech: Interactional participation and language acquisition. *Science, 183,* 99–101.

Conrad, R. (1962). An association between memory errors and errors due to acoustic masking of speech. *Nature, 193,* 1314–1315.

———. (1964). Acoustic confusions in immediate memory. *British Journal of Psychology, 55,* 75–84.

———. (1971). The chronology of the development of covert speech in children. *Developmental Psychology, 5,* 398–405.

———. (1972). Short-term memory in the deaf: A test for speech coding. *British Journal of Psychology, 63,* 173–180.

Cook, S. (1946). Human sacrifice and warfare as factors in the demography of pre-colonial Mexico. *Human Biology, 18,* 81–102.

Cornell, E. H. (1984). Developmental continuity of memory mechanisms: Suggestive phenomena. In R. Kail & N. E. Spear (Eds.), *Comparative perspectives on the development of memory.* Hillsdale, NJ: Lawrence Erlbaum.

Cowan, W. M. (1979). The development of the brain. *Scientific American, 241,* 112–133.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11,* 671–684.

Crain, W. C. (1980). *Theories of development: Concepts and applications.* Englewood Cliffs, NJ: Prentice-Hall.

Crook, J. H. (1980). *The evolution of human consciousness.* New York: Oxford University Press.

Cross, H. A., & Harlow, H. F. (1965). Prolonged and progressive effects of partial isolation on the behavior of macaque monkeys. *Journal of Experimental Research in Personality, 1,* 39–49.

Daehler, M. W., & Bukatko, D. (1985). *Cognitive development.* New York: Knopf.

Dale, P. S. (1976). *Language development.* New York: Holt, Rinehart and Winston.

Daly, M., & Wilson, M. (1978). *Sex, evolution and behavior.* Boston: Duxbury Press.

D'Amato, M. R. (1973). Delayed matching and short-term memory in monkeys. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in theory and research,* vol. 7. New York: Academic Press.

D'Andrade, R. (1966). Cross-cultural studies of sex differences in behavior. In E. Maccoby (Ed.), *The development of sex differences.* Stanford: Stanford University Press.

Dart, R. A. (1925). *Australopithecus africans:* The man-ape of South Africa. *Nature, 115,* 195–199.

Darwin, C. (1845). *Journal of researches into the natural history and geology of the countries visited during the voyage of H. M. S. Beagle round the world, under the command of Captain Fitz Roy, R. N.* London: John Murray.

———. (1859). *On the origin of species by means of natural selection; or, the preservation of favored races in the struggle for life.* London: John Murray.

———. (1871). *The descent of man, and selection in relation to sex.* London: John Murray.

———. (1967). *The expression of the emotions in Man and animals.* Chicago & London: The University of Chicago Press. (Original work published 1872.)

Darwin, C. T., Turvey, M. T., & Crowder, R. G. (1972). An auditory analogue of the Sperling partial report procedure: Evidence for brief auditory storage. *Cognitive Psychology, 3,* 255–267.

Davis, J. M. (1978). Dopamine theory of schizophrenia: A two-factor theory. In L. C. Wynne, R. L. Cromwell, & S. Matthysse (Eds.), *The nature of schizophrenia: New approaches to research and treatment.* New York: Wiley.

Dawkins, R. (1976). *The selfish gene.* New York & Oxford: Oxford University Press.

DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mothers' voices. *Science, 208,* 1174–1176.

DeFries, J. C., & Plomin, R. (1978). Behavioral genetics. *Annual Review of Psychology, 28,* 473–515.

Dement, W. (1960). The effect of dream deprivation. *Science, 131,* 1705–1707.

Dement, W., & Wolpert, E. (1958). Relation of eye movements, bodily motility, and external stimuli to dream content. *Journal of Experimental Psychology, 55,* 543–553.

Dempster, F. N. (1981). Memory span: Sources of individual and developmental differences. *Psychological Bulletin, 89,* 63–100.

Denenberg, V. H. (1963). Early experience and emotional development. *Scientific American, 208,* 138–146.

Dennis, W., & Dennis, M. G. (1940). The effect of cradling upon the onset of walking in Hopi children. *Journal of Genetic Psychology. 56,* 77–86.

———. (1941). Infant development under conditions of restricted practice and minimum social stimulation. *Genetic Psychology Monographs, 23,* 149–155.

Denny, M. R. (1980). *Comparative psychology.* New York: John Wiley.

Dentan, R. K. (1968). *The Semai: A nonviolent people of Malaya.* New York: Holt, Rinehart and Winston.

Desor, J. A., Maller, O., & Turner, R. (1973). Taste in acceptance of sugars by human infants. *Journal of Comparative and Physiological Psychology, 84,* 496–501.

Deutsch, A. (1946). *The mentally ill in America.* New York: Columbia University Press.

DeValois, R. L. (1965). Analysis and coding of color vision in the primate visual system. *Cold Spring Harbor Symposium on Quantitative Biology, 30,* 567–579.

Dewsbury, D. A. (1978). *Comparative animal behavior.* New York: McGraw-Hill.

Dickinson, A., & Mackintosh, N. J. (1978). Classical conditioning in animals. *Annual Review of Psychology, 29,* 587–612.

Dilger, W. C. (1962). The behavior of lovebirds. *Scientific American, 206,* 88–98.

Dion, K. K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personal and Social Psychology, 24,* 285–290.

Dobzhansky, T., Ayala, F., Stebbins, G., & Valentine, J. W. (1977). *Evolution.* San Francisco: Freeman.

Dollard, J., & Miller, N. E. (1950). *Personality and psychotherapy.* New York: McGraw-Hill.

Dollard, J., Doob, L., Miller, N., Mowrer, O. H., & Sears, R. R. (1939). *Frustration and aggression.* New Haven: Yale University Press.

Donaldson, M. (1979). The mismatch between school and children's minds. *Human Nature, 2,* 60–67.

Dorfman, D. D. (1978). The Cyril Burt question: New findings. *Science, 201,* 1177–1186.

Duncker, K. (1945). On problem solving. *Psychological Monographs, 58,* 5 (no. 270).

Dutton, P. G., & Aron, A. P. (1974). Some evidence for heightened sexual attraction under conditions of high anxiety. *Journal of Personality and Social Psychology, 30,* 510–517.

Eckhardt, R. B. (1979). *The study of human evolution.* New York: McGraw-Hill.

Eibl-Eibesfeldt, I. (1975). *Ethology: The biology of behavior.* New York: Holt, Rinehart and Winston.

Eimas, P. D. (1975). Speech perception in early infancy. In L. B. Cohen & P. Salapatek (Eds.), *Infant perception: From sensation to cognition,* vol. 2. New York: Academic Press.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotions. *Journal of personality and Social Psychology, 17,* 124–129.

Ekman, P., & Oster, H. (1979). Facial expressions of emotion. *Annual Review of Psychology, 30,* 527–554.

Elias, M. F., Elias, P. K., & Elias, J. W. (1977). *Basic processes in adult developmental psychology.* St. Louis: Mosby.

Ellis, A. (1962). *Reason and emotion in psychotherapy.* Secaucus, NJ: Citadel.

Ellis, N. R. (1970). Memory processes in retardates and normals. In N. R. Ellis (Ed.), *International review of research in mental retardation,* Vol. 4. New York: Academic Press.

Emlen, S. (1978). Cooperative breeding. In J. Krebs & N. Davis (Eds.), *Behavioral ecology.* Oxford: Blackwell.

Epstein, A. N. (1982). Instinct and motivation as explanations for complex behavior. In D. W. Pfaff (Ed.), *The physiological mechanisms of motivation.* New York: Springer-Verlag.

Epstein, A. N., & Teitelbaum, P. (1962). Regulation of food intake in the absence of taste, smell, and other oropharyngeal sensations. *Journal of Comparative and Physiological Psychology, 55,* 753–759.

Eron, L. D., Lefkowitz, M. M., Huesmann, L. R., & Walder, L. O. (1972). Does television violence cause aggression? *American Psychologist, 27,* 253–263.

Eysenck, H. J. (1960). *Behaviour therapy and the neuroses.* London: Pergamon Press.

———. (1961). The effects of psychotherapy. In H. J. Eysenck (Ed.), *Handbook of abnormal psychology.* New York: Basic Books.

———. (1967). *The biological basis of personality.* Springfield, IL: Charles C. Thomas.

Fabre, J. H. (1949). The life of the caterpillar. Excerpt in E. W. Teale, *The insect world of J. Henri Fabre.* New York: Dodd, Mead & Co., pp. 10–24.

Fagan, J. F. (1973). Infants' delayed recognition memory and forgetting. *Journal of Experimental Child Psychology, 16,* 424–450.

Farber, S. (1981). Telltale behavior of twins. *Psychology Today, 15,* 58.

Farley, J., & Alkon, D. L. (1985). Cellular mechanisms of learning, memory, and information storage. *Annual Review of Psychology, 36,* 419–494.

Feldman, H., Goldin-Meadow, S., & Gleitman, L. R. (1978). Beyond Herodotus: The creation of language by linguistically deprived deaf children. In A. Lock (Ed.), *Action, gesture, and symbol: The emergence of language.* New York: Academic Press.

Fenz, W. D. (1971). Heart rate responses to a stressor: A comparison between primary and secondary psychopaths and normal controls. *Journal of Experimental Research on Personality, 5,* 7–13.

Festinger, L. A. (1957). *A theory of cognitive dissonance.* Stanford: Stanford University Press.

Field, T. M., Dempsey, J. R., Hatch, J., Ting, G., & Clifton, R. K. (1979). Cardiac and behavioral responses to repeated tactile and auditory stimulation by preterm and term neonates. *Developmental Psychology, 15,* 406–416.

Field, T. M., Woodson, R., Greenberg, R., & Cohen, D. (1982). Discrimination and imitation of facial expressions by neonates. *Science, 218,* 179–181.

Fitzgerald, H. E., & Brackbill, T. (1976). Classical conditioning in infancy: Development and constraints. *Psychological Bulletin, 83,* 353–376.

Flaherty, C. F., Hamilton, L. W., Gandelman, R. J., & Spear, N. E. (1977). *Learning and memory.* Chicago: Rand McNally.

Flavell, J. H. (1970). Developmental studies of mediated memory. In H. W. Reese & L. P. Lipsitt (Eds.), *Advances in child development and behavior,* vol. 5. New York: Academic Press.

———. (1977). *Cognitive development.* Englewood Cliffs, NJ: Prentice-Hall.

———. (1985). *Cognitive development* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Flavell, J. H., & Wellman, H. M. (1977). Metamemory. In R. V. Kail & J. W. Hager (Eds.), *Perspectives on the development of memory and cognition.* Hillsdale, NJ: Lawrence Erlbaum.

Fleming, J. D. (1974). Field report: The state of the apes. *Psychology Today, 7,* 31–46.

Fowler, H., & Whalen, R. E. (1961). Variation in incentive stimulus and sexual behavior in the male rat. *Journal of Comparative and Physiological Psychology, 54,* 68–71.

Freedman, D. G. (1974). *Human infancy: An evolutionary perspective.* Hillsdale, NJ: Lawrence Erlbaum.

———. (1982). Ethnic differences in babies. In H. E. Fitzgerald & T. H. Carr (Eds.), *Human development, 82/83.* Guilford, CT: Dushkin.

Freedman, D. G., & Keller, B. (1963). Inheritance of behavior in infants. *Science, 140,* 196–198.

Freedman, J., Klevansky, S., & Ehrlich, P. (1971). The effect of crowding on human task performance. *Journal of Applied Social Psychology, 1,* 7–25.

Freedman, J. D., Sears, D. O., & Carlsmith, J. M. (1981). *Social Psychology* (4th ed.). Englewood Cliffs, NJ: Prentice-Hall.

Freud, S. (1965). *The interpretation of dreams.* New York: Avon Books. (Original work published 1900.)

Friedman, S., Bruno, L. A., & Vietze, P. (1974). Newborn habituation to visual stimuli: A sex difference in novelty detection. *Journal of Experimental Child Psychology, 18,* 242–251.

Fuller, J. L., & Thompson, W. R. (1960). *Behavior genetics.* New York: Wiley.

———. (1978). *Foundations of behavior genetics.* St. Louis: C. V. Mosby.

Galton, F. (1869) *Hereditary genius.* London: Macmillian.

Garcia, J., Ervin, F. R., & Koelling, R. A. (1966). Learning with prolonged delay of reinforcement. *Psychonomic Science, 5,* 121–122.

Garcia, J., Hankins, W. G., & Rusiniak, K. W. (1974). Behavioral regulation of the *milieu interne* in man and rat. *Science, 185,* 824–831.

Garcia, J., & Koelling, R. A. (1966). Relation of cue to consequence in avoidance learning. *Psychonomic Science, 4,* 122–124.

Gardner, H. (1982). *Developmental psychology* (2nd ed.). Boston: Little, Brown.

Gardner, R. A., & Gardner, B. T. (1969). Teaching sign language to a chimpanzee. *Science, 165,* 664–672.

Garrick, N. A., Tamarkin, L., Taylor, P. L., Markey, S. P., & Murphy, D. L. (1983). Light and propranol suppress the nocturnal elevation of serotonin in the cerebrospinal fluid of rhesus monkeys. *Science, 221,* 474–476.

Gazzaniga, M. S. (1967). The split brain in man. *Scientific American, 217,* 24–29.

Geen, R. G., & Quanty, M. B. (1977). The catharsis of aggression: An evaluation of a hypothesis. In L. Berkowitz (Ed.), *Advances in experimental social psychology,* vol. 10. New York: Academic Press.

Gelman, R. (1978). Cognitive development. *Annual Review of Psychology, 29,* 297–332.

———. (1979). Preschool thought. *American Psychologist, 34,* 900–905.

Gerbner, G., Gross, L., Eleey, M. F., Jackson Beeck, M., Jeffries-Fox, S., & Signorielli, N. (1977). TV violence profile no. 8: The highlights. *Journal of Communication, 27* (2), 171–180.

Gesell, A. (1925). *The mental growth of the preschool child.* New York: Macmillian.

Gesell, A., & Thompson, H. (1929). Learning and maturation in identical infant twins: An experimental study by the method of co-twin control. *Genetic Psychology Monographs, 6,* 1–124.

Gibson, E. J., & Walk, R. D. (1960). The "visual cliff." *Scientific American, 202,* 64–71.

Gibson, J. J. (1950). *The perception of the visual world.* Boston: Houghton Mifflin.

———. (1979). *The ecological approach to visual perception.* Boston: Houghton-Mifflin.

Ginsburg, H., & Koslowski, B. (1976). Cognitive development. *Annual Review of Psychology, 27,* 29–61.

Gintzler, A. R. (1980). Endorphin-mediated increases in pain threshold during pregnancy. *Science, 210,* 193–195.

Glanzer, M., & Cunitz, A. R. (1966). Two storage mechanisms in free recall. *Journal of Verbal Learning and Verbal Behavior, 5,* 351–360.

Goddard, H. H. (1912). *The Kallikak family.* New York: Macmillan.

Golding-Meadow, S., & Mylander, C. (1983). Gestural communication by deaf children: Noneffect of parental input on language development. *Science,* 1983, *221,* 372–374.

Goldstein, E. B. (1984). *Sensation and perception.* Belmont, CA: Brooks/Cole.

Goleman, D. (May 12, 1985). Insights into self-deception. *The New York Times Magazine,* 36–43.

Gottesman, I. I., & Shields, J. (1982). *The schizophrenic puzzle.* New York: Cambridge University Press.

Gottfried, A. W., & Rose, S. A. (1980). Tactile recognition memory in infants. *Child Development, 51,* 69–74.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics.* New York: John Wiley.

Gregory, R. L. (1972). *Eye and brain: The psychology of seeing.* New York: World University Library.

Gross, T. F. (1985). *Cognitive development,* Monterey, CA: Brooks/Cole.

Grossman, H. (Ed.). (1973). *Manual on terminology* *and classification in mental retardation, 1973 revision.* Washington, D.C.: American Association on Mental Deficiency.

Gruber, H. E., & Barrett, P. H. (1974). *Darwin on man.* New York: E. P. Dutton.

Guilford, J. P. (1967). *The nature of human intelligence.* New York: McGraw-Hill.

———. (1968). Intelligence has three facets. *Science, 160,* 615–620.

Hall, K. R. L. (1960). Social vigilance behavior of the Chacma baboon (*Papio ursinus*). *Behavior, 16,* 261–294.

Hamilton, W. D. (1964). The genetical theory of social behavior: I and II. *Journal of Theoretical Biology, 7,* 1–52.

Hanson, V. L. (1982). Short-term recall by deaf signers of American Sign Language: Implications of encoding strategy for order recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 572–583.

Harlow, H. F. (1949). The formation of learning sets. *Psychological Review, 56,* 51–65.

———. (1965). Sexual behavior in rhesus monkeys. In F. A. Beach (Ed.), *Sex and behavior.* New York: Wiley.

Harlow, H. F., & Harlow, M. K. (1962). Social deprivation in monkeys. *Scientific American, 207,* 137–146.

Harris, B. (1979). Whatever happened to little Albert? *American Psychologist, 34,* 151–160.

Harris, M. (1977). *Cannibals and kings: The origins of cultures.* New York: Random House.

Harthshorne, H., & May, M. S. (1928). *Studies in the nature of character.* New York: Macmillan.

Hassett, J. (1978). Sex and smell. *Psychology Today, 12,* 40–45.

Hay, D. F. (1980). Multiple functions of proximity seeking in infancy. *Child Development, 51,* 636–645.

Hayes, K. J., & Hayes, C. (1951). Intellectual development of a home-raised chimpanzee. *Proceedings of the American Philosophical Society, 95,* 105–109.

Heath, R. G. (1972). Electrical self-stimulation of the brain in man. In G. B. Bishop & W. F. Hill (Eds.), *Dimension of psychology.* Philadelphia: J. B. Lippincott.

Hebb, D. O. (1949). *The organization of behavior.* New York: Wiley.

Heider, E. R. (1972). Universals in color naming and memory. *Journal of Experimental Psychology, 93,* 10–20.

Held, R., & Hein, A. (1963). Movement-produced stimulation in the development of visually guided behavior. *Journal of Comparative & Physiological Psychology, 56,* 872–876.

Hellman, H. (1982). Guiding light. *Psychology Today, 16,* 22–28.

Henderson, N. D. (1982). Human behavior genetics. *Annual Review of Psychology, 33,* 403–440.

Heston, L. L. (1966). Psychiatric disorders in foster home reared children of schizophrenic mothers. *British Journal of Psychiatry, 112,* 819–825.

Hetherington, E. M., & Parke, R. D. (1979). *Child psychology: A contemporary viewpoint* (2nd ed.). New York: McGraw-Hill.

Hinde, R. A. (1970). *Animal behaviour* (2nd ed.). New York: McGraw-Hill.

———. (1974). *Biological bases of human social behavior.* New York: McGraw-Hill.

Hill, C. T., Rubin, Z., & Peplau, L. A. (1976). Breakups before marriage: The end of 103 affairs. *Journal of Social Issues, 32,* 147–168.

Hockett, C. F. (1960). The origin of speech. *Scientific American, 203,* 88–96.

Hockey, G. R. J., Davies, S., & Gray, M. M. (1972). Forgetting as a function of sleep at different times of day. *Quarterly Journal of Experimental Psychology, 24,* 386–393.

Hofer, M. A. (1981). *The roots of human behavior: An introduction to the psychobiology of early development.* San Francisco: Freeman.

Hoffman, H. S. (1978). Experimental analysis of imprinting and its behavioral effects. In G. H. Bower (Ed.), *The psychology of learning and motivation,* vol. 12. New York: Academic Press.

Hoffman, M. L. (1975). Developmental synthesis of affect and cognition and its implications for altruistic motivation. *Developmental Psychology, 11,* 607–622.

Hohmann, G. W. (1966). Some effects of spinal cord lesions on experienced emotional feelings. *Psychophysiology, 3,* 143–156.

Holden, C. (1980). Identical twins reared apart. *Science, 207,* 1323–1326.

Honzik, M. P. (1976). Value and limitations of infant tests: An overview. In M. L. Lewis (Ed.), *Origins of intelligence: Infancy and early childhood.* New York: Plenum.

Horner, M. (1972). The motive to avoid success and changing aspirations of college women. In J. M. Bardwick (Ed.), *Readings on the psychology of women.* New York: Harper & Row, pp. 62–67.

Horton, D. L. & Mills, C. B. (1984). Human learning and memory. *Annual Review of Psychology, 35,* 361–394.

Howe, M. J. A. (1980). *The psychology of human learning.* New York: Harper & Row.

Hoyenga, K. B., & Hoyenga, K. T. (1984). *Motivational explanations of behavior: Evolutionary, physiological, and cognitive ideas.* Monterey, CA: Brooks/Cole.

Hubel, D. H. (1979). The brain. *Scientific American, 241,* 44–53.

Hubel, D. H., & Wiesel, T. N. (1959). Receptive fields of single neurons in the cat's striate cortex. *Journal of Physiology, 147,* 226–238.

Hull, C. L. (1943). *Principles of behavior,* New York: Appleton-Century-Crofts.

———. (1945). The place of innate individual and species differences in a natural science theory of behavior. *Psychological Review, 52,* 55–60.

———. (1952). *A behavior system.* New Haven: Yale University Press.

Hultsch, D. F. (1974). Learning to learn in adulthood. *Journal of Gerontology, 29,* 302–308.

Hunt, E., Frost, N., & Lunneborg, C. (1973). Individual differences in cognition: A new approach to intelligence. In G. H. Bower (Ed.), *The psychology of learning and motivation,* vol. 7. New York: Academic Press.

Hunt, E., Lunneborg, C., & Lewis, J. (1975). What does it mean to be high verbal? *Cognitive Psychology, 7,* 194–227.

Hunt, J. M. (1961). *Intelligence and experience.* New York: Ronald Press.

Huston, T. L., & Levinger, G. (1978). Interpersonal attraction and relationships. *Annual Review of Psychology, 29,* 115–156.

Iannotti, R. J. (1978). Effect of role-taking experiences on role-taking, empathy, altruism, and aggression. *Developmental Psychology, 14,* 119–124.

Izard, C. (1971). *The face of emotion.* New York: Appleton-Century-Crofts.

Jacobson, S. W. (1979). Matching behavior in the young infant. *Child Development, 50,* 425–430.

James, W. (1890). *The principles of psychology.* New York: Holt.

Janis, I. L., Mahl, G. F., Kagan, J., & Holt, R. R. (1969). *Personality: Dynamics, development, and assessment.* New York: Harcourt, Brace, & World.

Jenkins, H. M., & Moore, B. A. (1973). The form of the auto-shaped response with food or water reinforcers. *Journal of the Experimental Analysis of Behavior, 20,* 163–181.

Jenkins, J. G., & Dallenbach, K. M. (1924). Oblivescence during sleep and waking. *American Journal of Psychology, 35,* 605–612.

Jenkins, R. L. (1968). The varieties of children's behavioral problems and family dynamics. *American Journal of Psychiatry, 124,* 1440–1445.

———. (1969). Classification of behavior problems of children. *American Journal of Psychiatry, 125,* 1032–1039.

Jenkins, W. O., McFann, H., & Clayton, F. L. (1950). A methodological study of extinction following a periodic and continuous reinforcement. *Journal of Comparative and Physiological Psychology, 43,* 155–167.

Jensen, A. R. (1969). How much can we boost IQ and scholastic achievement? *Harvard Educational Review, 39,* 1–123.

Jerison, H. J. (1973). *Evolution of the brain and intelligence.* New York: Academic Press.

Joffe, J. M. (1969). *Prenatal determinants of behavior.* Oxford: Pergamon.

Johanson, D. C. (December 1976). Ethiopia yields first "family" of man. *National Geographic,* 790–811.

Johanson, D. C., Lovejoy, C. O., Burstein, A. H., & Heiple, K. G. (1976). Functional implications of the Afar knee joint. *American Journal of Physical Anthropology, 44,* 188.

Jones, H. E. (1930). The galvanic skin reflex in infancy. *Child Development, 1,* 106–110.

Jones, M. C. (1924). A laboratory study of fear: The case of Peter. *Pedagogical Seminar and Journal of Genetic Psychology, 31,* 308–315.

Jonides, J., Irwin, D. E., & Yantis, S. (1982). Integrating visual information from successive fixations. *Science, 215,* 192–194.

Jouvet, M. (1967). Neurophysiology of the states of sleep. *Psychological Review, 47,* 117–177.

Jung, C. G. (1964). Approaching the unconscious. In C. G. Jung (Ed.), *Man and his symbols.* New York: Dell.

Kail, R. (1979). *The development of memory in children.* San Francisco: Freeman.

Kamil, A. C., & Roitblat, H. L. (1985). The ecology of foraging behavior: Implications for animal learning and memory. *Annual Review of Psychology. 36,* 141–169.

Kandel, D. B. (1978). Similarity in real-life adolescent friendship pairs. *Journal of Personality and Social Psychology, 36,* 306–312.

Kaufman, L., & Rock, I. (1962). The moon illusion. *Scientific American, 207,* 120–130.

Kay, P. (1975). Synchronic variability and diachronic changes in basic color terms. *Language in Society, 4,* 257–270.

Kaye, H. (1967). Infant sucking and its modification. In L. P. Lipsitt & C. C. Spiker (Eds.), *Advances in child development and behavior,* vol. 3. New York: Academic Press.

Kempe, R. S., & Kempe, H. C. (1978). *Child abuse.* Cambridge: Harvard University Press.

Kennedy, W. A. (1969). A follow-up normative study of Negro intelligence and achievement. *Monographs of the Society for Research in Child Development, 34,* serial no. 126.

Kennedy, W. A., Van de Riet, V., & White, J. C. (1963). A normative sample of intelligence and achievement of Negro elementary school children in the southeastern United States. *Monographs of the Society for Research in Child Development, 28,* serial no. 6.

Kenny, J. T., & Blass, E. M. (1977). Suckling as incentive to instrumental learning in preweaning rats. *Science, 196,* 898–899.

Kesner, R. P., & Novak, J. M. (1982). Serial position curve in rats: Role of the dorsal hippocampus. *Science, 218,* 173–175.

Kessel, E. L. (1955). Mating activities of balloon flies. *Systematic Zoology, 4,* 97–104.

Kety, S. S., Rosenthal, D., Wender, P. H., Schulsinger, F., & Jacobsen, B. (1976). Mental illness in the biological and adoptive families of adopted individuals who have become schizophrenic. *Behavior Genetics, 6,* 219–225.

Kingsley, P. R., & Hagen, J. W. (1969). Induced versus spontaneous rehearsal in short-term memory in nursery school children. *Developmental Psychology, 1,* 40–46.

Kinsbourne, M., & Smith, W. L. (Eds.). (1974). *Hemispheric disconnection and cerebral function.* Springfield, IL: Charles C. Thomas.

Kinsey, A. C., Pomeroy, W. B., & Gerhard, P. H. (1953). *Sexual behavior in the human female.* Philadelphia and London: W. B. Saunders.

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behavior in the human male.* Philadelphia and London: W. B. Saunders.

Klatzky, R. L. (1980). *Human memory: Structures and processes.* San Francisco: Freeman.

———. (1984). *Memory and awareness: An information-processing perspective.* New York: Freeman.

Klaus, M. H., & Kennell, J. H. (1976). *Maternal-infant bonding.* St. Louis: Mosby.

Kline, D. W., & Birren, J. E. (1975). Age differences in dichoptic masking. *Experimental Aging Research, 1,* 17.

Kline, D. W., & Szafran, J. (1975). Age differences in backward monoptic visual noise masking. *Journal of Gerontology, 30,* 307.

Klopfer, B., & Davidson, H. (1962). *The Rorschach technique: An introductory manual.* New York: Harcourt Brace Jovanovich.

Kobasigawa, A. (1974). Utilization of retrieval cues by children in recall. *Child Development, 45,* 127–134.

Kolers, P. A. (1983). Perception and representation. *Annual Review of Psychology, 34,* 129–166.

Konishi, M. (1978). Auditory environment and vocal development in birds. In R. D. Walk & H. L. Pick, Jr. (Eds.), *Perception and experience.* New York: Plenum.

Kosslyn, S. M., Ball, T. M., & Reiser, B. J. (1978). Visual images preserve metric spatial information: Evidence from studies of image scanning. *Journal of Experimental Psychology: Human Perception and Performance, 4,* 47–60.

Kretschmer, E. (1925). *Physique and character.* New York: Harcourt, Brace, & World.

Kuhlman, F. (1922). *A handbook of mental tests.* Baltimore: Warwick & York.

LaBarba, R. C. (1981). *Foundations of developmental psychology.* New York: Academic Press.

Lachman. J. L., & Lachman, R. (1979). Theories of memory organization and human evolution. In C. R. Puff (Ed.), *Memory organization and structure.* New York: Academic Press.

Lacoste-Utamsing, C., & Holloway, R. L. (1982). Sexual dimorphism in the human corpus callosum. *Science, 216,* 1431–1432.

Lade, B. I., & Thorpe, W. H. (1964). Dove songs as innately coded patterns of specific behavior. *Nature, 202,* 366–368.

Lahey, B. B., & Ciminero, A. R. (1980). *Maladaptive behavior: An introduction to abnormal psychology.* Glenview, IL: Scott, Foresman.

Lamberth, J. (1980). *Social psychology.* New York: Macmillan.

Landy, D., & Aronson, E. (1969). The influence of the character of the criminal and his victim on the decisions of simulated jurors. *Journal of Experimental Social Psychology, 5,* 141–152.

Leakey, L. S. B., Tobias, P. V., & Napier, J. R. (1964). A new species of the genus Homo from Olduvai Gorge. *Nature, 202,* 7–9.

Leakey, R. E. (June 1973). Skull 1470. *National Geographic,* 819–829.

Leakey, R. E., & Lewin, R. E. (1977). *Origins.* New York: Dutton.

———. (1978). *People of the lake.* Garden City, NY: Anchor Press/Doubleday.

Leaton, R. N., & Tighe, T. J. (1976). Comparisons between habituation research at the developmental and animal-neuropsychological levels. In R. N. Leaton & T. J. Tighe (Eds.), *Habituation: Perspectives from child development, animal behavior, and neurophysiology.* Hillsdale, NJ: Lawrence Erlbaum.

Lenneberg, E. H. (1967). *Biological foundations of language.* New York: Wiley.

———. (1969). On explaining language. *Science, 164,* 635–643.

Levine, L. (1958). Studies on sexual selection in mice: I. Reproductive competition between albino and black-agouti males. *American Naturalist, 92,* 21–26.

Levy, J. (1985). Right brain, left brain: Fact and fiction. *Psychology Today, 19,* 38–44.

Lewin, R. (1984). Practice catches theory in kin selection. *Science, 223,* 1049–1051.

Lewis, J. W., Cannon, J. T., & Liebeskind, J. C. (1980). Opioid and nonopioid mechanisms of stress and analgesia. *Science, 208,* 623–625.

Lidz, T., Cornelison, A. R., Terry, D., & Fleck, S. (1958). Irrationality as a family tradition. *AMA Archives of Neurological Psychiatry, 79,* 305–316.

Liebert, R. M., Poulos, R. W., & Strauss, G. D. (1974). *Developmental psychology.* Englewood Cliffs, NJ: Prentice-Hall.

Liebert, R. M., Sprafkin, J. N., & Davidson, E. S. (1982). *The early window: Effects of television on children and youth* (2nd ed.). New York: Pergamon Press.

Liebert, R. M., & Wicks-Nelson, R. (1981). *Developmental psychology* (3rd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Lindsay, P. H., & Norman, D. A. (1972). *Human information processing: An introduction to psychology.* New York: Academic Press.

Loftus, E. F. (1979). *Eyewitness testimony.* Cambridge: Harvard University Press.

Loftus, G. R., Johnson, C. A., & Shimamura, A. P. (1985). How much is an icon worth? *Journal of Experimental Psychology: Human Perception and Performance, 11,* 1–13.

Lorenz, K. (1937). The companion in the bird's world. *Auk, 54,* 245–273.

———. (1966). *On aggression.* London: Methuen & Co.

———. (1981). *The foundations of ethology.* New York: Springer-Verlag.

Lovaas, O. I., Schaeffer, B., & Simmons, J. Q. (1965). Building social behavior in autistic children by use of electric shock. *Journal of Experimental Research in Personality, 1,* 99–109.

Luchins, A. S. (1942). Mechanization in problem solving. *Psychological Monographs. 54,* no. 248.

Lytton, H. (1977). Do parents create, or respond to, differences in twins? *Developmental Psychology, 13,* 456–459.

Maccoby, E. F., & Jacklin, C. N. (1974). *The psychology of sex differences.* Stanford: Stanford University Press.

Macfarland, J. A. (1975). Olfaction in the development of social preferences in the human neonate. *Parent-infant interaction.* Symposium published by the CIBA Foundation, no. 33, new series, ASP.

Macfarlane, A. (1977). *The psychology of childbirth.* Cambridge: Harvard University Press.

MacKinnon, D. W. (1962). The nature and nurture of creative talent. *American Psychologist, 17,* 484–495.

MacKworth, J. F. (1976). Development of attention. In V. Hamilton and M. D. Vernon (Eds.), *The development of cognitive processes.* London: Academic Press.

MacNeish, R. (1972). The evolution of community patterns in the Tehuacán Valley of Mexico, and speculation about the cultural processes. In P. J. Ucko, R. Tringham, & G. W. Dimbleby (Eds.), *Man, settlement, and urbanism.* Cambridge, MA: Schenkman.

Maier, R. A., & Maier, B. M. (1970). *Comparative animal behavior.* Belmont, CA: Brooks/Cole.

Maki, W. S.., Moe, J. C., & Bierley, C. M. (1977). Short-term memory for stimuli, responses, and reinforcers. *Journal of Experimental Psychology: Animal Behavior Processes, 3,* 156–177.

Maloney, M. P., & Ward, M. P. (1976). *Psychological assessment: A conceptual approach.* New York: Oxford University Press.

Mark, V. H., & Ervin, F. R. (1970). *Violence and the brain.* New York: Harper & Row.

Marler, P., & Hamilton, III, W. J. (1966). *Mechanisms of animal behavior.* New York: Wiley.

Marler, P., & Mundinger, P. (1971). Vocal learning in birds. In H. Moltz (Ed.), *The ontogeny of vertebrate behavior.* New York: Academic Press.

Marler, P., & Tamura, M. (1964). Culturally transmitted patterns of vocal behavior in sparrows. *Science, 146,* 1483–1486.

Martin, B., (1981). *Abnormal psychology* (2nd ed.). New York: Holt, Rinehart and Winston.

Martin, R. M. (1975). Effects of familiar and complex stimuli on infant attention. *Developmental Psychology, 11,* 178–185.

Martindale, C. (1981). *Cognition and consciousness.* Homewood, IL: Dorsey Press.

Maslach, C. (1979). The emotional consequences of arousal without reason. In C. E. Izard (Ed.), *Emotions in personality and psychopathology.* New York: Plenum.

Massaro, D. W. (1970). Perceptual auditory images. *Journal of Experimental Psychology, 85,* 411–417.

Masters, W. H., & Johnson, V. E. (1966). *Human sexual response.* Boston: Little, Brown.

Matheny, A. P. (1980). Bayley's infant behavior record: Behavioral components and twin analyses. *Child Development, 51,* 1157–1167.

Matlin, M. (1983). Cognition. New York: Holt, Rinehart and Winston.

Maurer, D., & Salapatek, P. (1976). Developmental changes in the scanning of faces by young infants. *Child Development, 47,* 523–527.

Mayer, R. E. (1983). *Thinking, problem solving, cognition.* San Francisco: Freeman.

Mayr, E. (1963). *Animal species and evolution.* Cambridge: Harvard University Press.

———. (1970). *Population, species, and evolution.* Cambridge: Harvard University Press.

McCall, R. B. (1975). *Fundamental statistics for psychology* (2nd ed.). Harcourt Brace Jovanovich.

McCall, R. B., Applebaum, M. I., & Hogarty, P. S. (1973). Developmental changes in mental performance. *Monographs of the Society for Research in Child Development, 38,* serial no. 150.

McCall, R. B., Parke, R. D., & Kavanaugh, R. D. (1977). Imitation of live and televised models by children one to three years of age. *Monographs of the Society for Research in Child Development, 42,* serial no. 173.

McClintock, M. K. (1971). Menstrual synchrony and suppression. *Nature, 229,* 244–245.

McCormick, D., & Thompson, R. F. (1984). Cerebellum: Essential involvement in the classically conditioned eyelid response. *Science, 223,* 296–299.

McGaugh, J. L., & Herz, M. J. (1972). *Memory consolidation.* San Francisco: Albion.

McGraw, M. B. (1935). *Growth: A study of Johnny and Jimmy.* New York: Appleton-Century.

———. (1939). Later development of children specially trained during infancy: Johnny and Jimmy at school age. *Child Development, 10,* 1–19.

McPhee, J. (1977). *Coming into the country.* New York: Farrar, Straus, & Giroux.

Mead, M. (1969). How do children learn to govern their own violent impulses? *American Journal of Orthopsychiatry, 39,* 227–229.

Mednick, S. A. (1964). *Learning.* Englewood Cliffs: Prentice-Hall.

Mednick, S. A., Gabrielli, Jr., W. F., & Hutchings, B. (1984). Genetic influences in criminal convictions: Evidence for an adoption cohort. *Science, 224,* 891–894.

Mednick, S. A., Schulsinger, F., & Garfinkel, R. (1975). Children at high risk for schizophrenia: Predisposing factors and intervention. In M. L. Kietzman, S. Suttion, & J. Zubin (Eds.), *Experimental approaches to psychopathology.* New York: Academic Press.

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198,* 75–78.

Menzel, Jr., E. W., & Juno, C. (1982). Marmosets (*Saquinas fuscicollis*): Are learning sets learned? *Science, 217,* 750–752.

Mervis, C. B., & Crisafi, M. A. (1982). Order of acquisition of subordinate-, basic-, and superordinate-level categories. *Child Development, 53,* 258–266.

Milgram. S. (1963). Behavioral study of obedience. *Journal of Abnormal and Social Psychology, 67,* 371–378.

Miller, G. A. (1981). *Language and speech.* San Francisco: Freeman.

Miller, N. E., & Dollard, J. (1941). *Social learning and imitation.* New Haven: Yale University Press.

Minimi, H., & Dallenbach, K. M. (1946). The effect of activity upon learning and retention in the cockroach. *American Journal of Psychology, 59,* 1–58.

Mischel, W. (1968). *Personality and assessment.* New York: Wiley.

———. (1976). *Introduction to personality.* New York: Holt, Rinehart and Winston.

———. (1979). On the interface of cognition and personality: Beyond the person-situation debate. *American Psychologist, 34,* 740–754.

Miselis, R. R., & Epstein, A. N. (1970). Feeding induced by 2-deoxy-D-glucose injections into the lateral ventricle of the rat. *The Physiologist, 13,* 262.

Missakian, E. (1969). Reproductive behavior of socially deprived male rhesus monkeys (*Macaca mulatta*). *Journal of Comparative and Physiological Psychology, 69,* 403–407.

Mitchell, G: (1973). Comparative development of social and emotional behavior. In G. Bermant (Ed.), *Perspectives on animal behavior.* Glenview, IL: Scott Foresman.

Mollon, J. D. (1982). Color vision. *Annual Review of Psychology, 33,* 41–85.

Moore, T. (1967). Language and intelligence: A longitudinal study of the first eight years. *Human Development, 10,* 88–106.

Moore-Ede, M. C., Sulzman, F. M., & Fuller, C. A. (1982). *The clocks that time us.* Cambridge: Harvard University Press.

Moray, N., Bates, A., & Barnett, T. (1965). Experiments on the four-eared man. *Journal of the Acoustical Society of America, 38,* 196–201.

Morley, J. E., & Levine, A. S. (1980). Stress-induced eating is mediated through endogenous opiates. *Science, 209,* 1259–1260.

Morris, N. M., & Udry, J. R. (1978). Pheromonal influences on human sexual behavior: An experimental search. *Journal of Biosocial Science, 10,* 147–157.

Morse, S. J., Gruzen, J., & Reis, H. (1976). The "eye of the beholder": A neglected variable in the study of physical attractiveness? *Journal of Personality, 44,* 209–225.

Mosiman, J. G., & Martin, P. S. (1975). Simulating overkill by Paleoindians. *American Scientist, 63,* 3.

Mucha, T. F., & Reinhardt, R. F. (1970). Conversion reactions in student aviators. *American Journal of Psychiatry, 127,* 493–497.

Munsinger, H. (1975). The adopted child's IQ: A critical review. *Psychological Bulletin, 82,* 623–659.

———. (1978). Reply to Kamin. *Psychological Bulletin, 85,* 202–206.

Murdock, B. B. (1974). *Human memory: Theory and data.* Hillsdale, N.J.: Lawrence Erlbaum.

Murdock, G. P. (1945). The common denominates of culture. In R. Linton (Ed.), *The science of man in the world crisis,* New York: Columbia University Press, 124–142.

Mussen, P. H., Conger, J. J., & Kagan, J. (1980). *Essentials of child development and personality.* New York: Harper & Row.

Myers, R. D. (1969). Temperature regulation: Neurochemical systems in the hypothalamus. In W. Haynaker, E. Anderson, & W. J. H. Nauto (Eds), *The hypothalamus.* New York: Charles C. Thomas.

Nagy, Z. M. (1979). Development of learning and memory processes in infant mice. In N. E. Spear & B. A. Campbell (Eds.), *Ontogeny of learning and memory.* Hillsdale, NJ: Lawrence Erlbaum.

Nash, R. (1973). *Wilderness and the American mind.* New Haven and London: Yale University Press.

Nathan, P. E., & Lipscomb, T. R. (1979). Behavior therapy and behavior modification in the treatment of alcoholism. In J. H. Mendelson & N. K. Mello (Eds.), *The diagnosis and treatment of alcoholism.* New York: McGraw-Hill.

Neale, J. M., Davison, G. C., & Price, K. P. (Eds.). (1978). *Contemporary readings in psychopathology* (2nd ed.). New York: Wiley.

Neisser, U. (Ed.). (1982). *Memory observed: Remembering in natural contexts.* San Francisco: Freeman.

Nelson, H., & Jurmain, R. (1982). *Introduction to physical anthropology.* St. Paul: West.

Nelson, T. O. (1977). Repetition and depth of processing. *Journal of Verbal Learning and Verbal Behavior, 16,* 151–172.

Newton, G., & Levine, S. (Eds.). (1968). *Early experience and behavior.* Springfield, IL: Charles C. Thomas.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84,* 231–259.

Nottebohm, F. (1972). The origins of vocal learning. *American Naturalist, 106,* 116–140.

Oller, D. K., Wieman, L. A., Doyle, W. J., & Ross, C. (1976). Infant babbling and speech. *Journal of Child Language, 3,* 1–11.

Orians, G. H. (1980a). Habitat selection: General theory and applications to human behavior. In J. S. Lockard (Ed.), *The evolution of human social behavior.* New York: Elsevier, 49–66.

———. (1980b). *Some adaptations of marsh-nesting blackbirds.* Princeton: Princeton University Press.

Ornstein, P. A. (1977). Memory development in children. In R. M. Leibert, R. W. Poulos, & G. S. Marmor, *Developmental psychology.* Englewood Cliffs, NJ: Prentice-Hall.

Ornstein, R. E. (1977). *The psychology of consciousness.* New York: Harcort Brace Jovanovich.

Osborn, A. F. (1963). *Applied imagination.* New York: Scribner's.

Osgood, C. E. (1953). *Method and theory in experimental psychology.* New York: Oxford University Press.

Ottinger, D. R., & Simmons, J. E. (1964). Behavior of human neonates and prenatal maternal anxiety. *Psychological Reports, 14,* 391–394.

Paivio, A. (1971). *Imagery and verbal processes.* New York: Holt, Rinehart and Winston.

Palmer, J. D. (October 1982). Biorhythm bunkum. *Natural History,* 90–99.

Papousek, H. (1959). A method of studying conditioned food reflexes in young children up to the age of six months. *Pavlov Journal of Higher Nervous Activity, 9,* 136–140.

———. (1967). Experimental studies of appetitional behavior in human newborns and infants. In H. W. Stevenson, E. Hess, & H. L. Rheingold (Eds.), *Early behavior: Comparative and developmental approaches.* New York: Wiley.

Parke, R. D., & Collmer, C. W. (1975). Child abuse: An interdisciplinary analysis. In E. M. Hetherington (Ed.), *Review of child development research,* vol. 5. Chicago: University of Chicago Press.

Parsons, J. E. (1980). Psychological neutrality: Is anatomy destiny? In J. E. Parsons (Ed.), *The psychobiology of sex differences and sex roles.* Washington, D.C.: Hemisphere.

Paul, G. L. (1966). *Insight versus desensitization in psychotherapy.* Stanford: Stanford University Press.

———. (1967). Insight versus desensitization in psychotherapy two years after termination. *Journal of Consulting Psychology, 31,* 333–348.

Pavlov. I. P. (1957). *Experimental psychology and other essays.* New York: Philosophical Library.

Penrod, S. (1983). *Social psychology.* Englewood Cliffs, NJ: Prentice-Hall.

Pert, A. (1981). The body's own tranquilizers. *Psychology Today, 15,* 100.

Pert, C. B., & Synder, S. H. (1973). Opiate receptor: Demonstration in nervous tissue. *Science, 179,* 1011–1014.

Petersen, A. C. (1980). Biopsychosocial processes in the development of sex-related differences. In J. E. Parsons (Ed.), *The psychobiology of sex differences and sex roles.* Washington, D.C.: Hemisphere.

Piaget, J. (1962). *Play, dreams, and imitation.* New York: Norton.

———. (1978). *Behavior and evolution.* New York: Random House.

Piaget, J., & Inhelder, B. (1973). *Memory and intelligence.* New York: Basic Books.

Poincaré, H. (1913). Mathematical creation (trans. G. H. Halstead). In *The foundations of science.* New York: Science Press.

Premack, D. (1972). Teaching language to an ape. *Scientific American, 227,* 92–99.

———. (1983). Animal cognition. *Annual Review of Psychology, 34,* 351–362.

Prochaska, J. O. (1979). *Systems of psychotherapy: A transtheoretical analysis.* Homewood, IL: Dorsey Press.

Rachman, S. (1977). The conditioning theory of fear-acquisition: A critical examination. *Behavior Research and Therapy, 15,* 375–388.

Rader, N., Spiro, D. J., & Firestone, P. B. (1979). Performance on a stage IV object-permanence task with standard and nonstandard covers. *Child Development, 50,* 908–910.

Reese, H. W. (1976). The development of memory: Lifespan perspectives. In H. W. Reese (Ed.), *Advances in child development and behavior,* vol. 11. New York: Academic Press.

Rescorla, R. A. (1968). Probability of shock in the presence or absence of CS in fear conditioning. *Journal of Comparative and Physiological Psychology, 66,* 1–5.

Rescorla, R. A., & Holland, P. C. (1982). Behavioral studies of associative learning in animals. *Annual review of psychology, 33,* 265–308.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), *Classical conditioning II: Current research and theory.* New York: Appleton-Century-Crofts.

Reynolds, A. G., & Flagg, P. W. (1983). *Cognitive psychology.* Boston: Little, Brown.

Rheingold, H. L., & Eckerman, C. O. (1973). Fear of the stranger: A critical examination. In H. W. Reese (Ed.), *Advances in child development and behavior,* vol. 8. New York: Academic Press.

Rheingold, H. L., Gewirtz, J. L, & Ross, H. W. (1959). Social conditioning of vocalization in the infant. *Journal of Comparative and Physiological Psychology, 52,* 68–73.

Rheingold, H. L., Hay, D. F., & West, M. J. (1976). Sharing in the second year of life. *Child Development, 47,* 1148–1158.

Riesen, A. H. (1973). Arrested vision. *The nature and nurture of behavior: Developmental psychobiology.* San Francisco: Freeman. (Originally published in *Scientific American,* 1950.)

———. (1965). Effects of early deprivation of photic stimulation. In S. Osler & R. Cooke (Eds.), *The biological basis of mental retardation.* Baltimore: Johns Hopkins University Press.

Riley, V., Spackman, D. H., & Fitzmaurice, M. A. (1981). *Psychoneuroimmunology.* New York: Academic Press.

Rimm, D., Janda, L. H., Lancaster, D. W., Nehl, M., & Dittmar, K. (1977). An exploratory investigation of the origin and maintenance of phobias. *Behavior Research and Therapy, 15,* 231–238.

Robinson, N. M., & Robinson, H. B. (1976). *The mentally retarded child.* New York: McGraw-Hill.

Rodin, J. (1981). Current status of the internal-external hypothesis for obesity: What went wrong? *American Psychologist, 36,* 361–372.

Roe, K. V., McClure, A., & Roe, A. (1982). Vocal interaction at 3 months and cognitive skills at 12 years. *Developmental Psychology, 18,* 15–16.

Roediger, III, H. L., & Crowder, R. G. (1976). A serial position effect in recall of United States presidents. *Bulletin of the Psychonomic Society, 8,* 275–278.

Roffwarg, H. P., Muzio, J. N., & Dement, W. C. (1966). Ontogenetic development of human sleep-dream cycle. *Science, 152,* 604–619.

Rogers, C. R. (1959). A theory of therapy, personality, and interpersonal relationships, as developed in the client-centered framework. In S. Koch (Ed.), *Psychology: A study of a science,* vol. 3. New York: McGraw-Hill.

Rosch, E. H. (1973). On the internal structure of perceptual and semantic categories. In T. E. Moore (Ed.), *Cognition and the acquisition of language.* New York: Academic Press.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382–439.

Rotter, J. B. (1966). Generalized expectancies for internal and external control of reinforcement. *Psychological Monographs, 80* (whole no. 609).

Routh, D. K. (1969). Conditioning of vocal response differentiation in infants. *Developmental Psychology, 1,* 219–226.

Rubin, K. H., & Schneider, F. W. (1973). The relationship between moral judgement, egocentrism, and altruistic behavior. *Child Development, 44,* 661–665.

Rubinstein, E. A. (1979). Television and the young viewer. *Readings in Human Development 79/80.*

Guilford, CT: Dushkin. (Originally published in *American Scientist,* 1978.)

Rudy, J. W., & Cheatle, M. D. (1979). Ontogeny of associative learning: Acquisition of odor aversions by neonatal rats. In N. E. Spear & B. A. Campbell (Eds.), *Ontogeny of learning and memory.* Hillsdale, NJ: Lawrence Erlbaum.

Rumbaugh, D. M. (Ed.). (1977). *Languae learning by a chimpanzee: The Lana project.* New York: Academic Press.

Rushton, J. P. (1984). Sociobiology: Toward a theory of individual and group differences in personality and social behavior. In J. R. Royce & L. P. Mos (Eds.), *Annals of theoretical psychology* (Vol. 2). New York: Plenum.

Russek, M. (1971). Hepatic receptors and the neurophysiological mechanisms controlling feeding behavior. In S. Ehrenpreis (Ed.), *Neurosciences Research,* vol. 4. New York: Academic Press.

Sackett, G. P., Holm, R. A., & Ruppenthal, G. C. (1976). Social isolation rearing: Species differences in behavior of macaque monkeys. *Developmental Psychology, 12,* 283–288.

Sagi, A., & Hoffman, M. L. (1976). Empathic distress in the newborn. *Developmental Psychology, 12,* 175–176.

Salapatek, P. (1975). Pattern perception in early infancy. In L. B. Cohen & P. Salapatek (Eds.), *Infant perception: From sensation to cognition,* vol. 1. New York: Academic Press.

Sameroff, A. J. (1968). The components of sucking in the human newborn. *Journal of Experimental Child Psychology, 6,* 607–623.

———. (1971). Can conditioned responses be established in the newborn infant? *Developmental Psychology, 5,* 1–12.

Sands, S. F., & Wright, A. A. (1982). Monkey and human pictorial memory scanning. *Science, 216,* 1333–1334.

Scarr, S. (1969). Social introversion-extroversion as a heritable response. *Child Development, 40,* 823–832.

Scarr, S., & Weinberg, R. A. (1976). IQ test performance of black children adopted by white families. *American Psychologist, 31,* 726–739.

———. (1977). Intellectual similarities within families of both adopted and biological children. *Intelligence, 1,* 170–191.

Scarr-Salapatek, S. (1976). An evolutionary perspective on infant intelligence: Species patterns and individual variations. In M. Lewis (Ed.), *Origins of intelligence: Infancy and early childhood.* New York: Plenum Press.

Schachter, S. (1971). Some extraordinary facts about obese humans and rats. *American Psychologist, 26,* 129–144.

Schachter, S., & Singer, J. E. (1962). Cognitive, social, and physicological determinants of emotional state. *Psychological Review, 69,* 379–399.

Schachter, S., & Wheeler, L. (1962). Epinephrine, chlopromazine, and amusement. *Journal of Abnormal and Social Psychology, 65,* 121–128.

Schacter, S. (1959). *The psychology of affiliation.* Stanford, CA: Stanford University Press.

Schaie, K. W., & Strother, J. (1968). For discussion of another basic methodology: Short-term longitudinal. *Psychological Bulletin, 70,* 671–680.

Schjelderup-Ebbe, T. (1935). Social behavior of birds. In C. Murchison (Ed.), *Handbook of social psychology.* Worcester, MA: Clark University Press.

Schmidt, D. E., & Keating, J. P. (1979). Human crowding and personal control: An integration of research. *Psychological Bulletin, 86,* 680–700.

Schreibman, L., & Koegel, R. L. (1981). A guideline for planning behavior modification programs for autistic children. In S. M. Turner, K. S. Calhoun, & H. E. Adams (Eds.), *Handbook of clinical behavior therapy.* New York: Wiley.

Schultz, A. H. (1968). The recent hominid primates. In S. Washburn & P. C. Jay (Eds.), *Perspectives on human evolution,* vol. 1. New York: Holt, Rinehart and Winston.

Schutz, F. (1965). Sexuelle Prägung bei Anatiden. *Z. Tierpsychol., 22,* 50–103.

Scott, J. P., & Fuller, J. L. (1965). *Genetics and the social behavior of the dog.* Chicago: University of Chicago Press.

Sears, R. R., Maccoby, E., & Levin, H. (1957). *Patterns of child rearing.* Evanston, IL: Row, Peterson.

Seligman, M. E. P. (1975). *Helplessness: On depression, development, and death.* San Francisco: Freeman.

Seligman, M. E. P., & Hager, J. L. (1972). *Biological boundaries of learning.* Englewood Cliffs, NJ: Prentice-Hall.

Selye, H. (1936). A syndrome produced by diverse nocuous agents. *Nature, 138,* 32.

Sevenster, P. (1968). Motivation and learning in sticklebacks. In D. Ingle (Ed.), *The central nervous system and fish behavior.* Chicago: University of Chicago Press.

Severy, J. L., & Davis, K. E. (1971). Helping-behavior among normal and retarded children. *Child Development, 42,* 1017–1031.

Seyfarth, R. M., Cheney, D. L., & Marler, P. (1980). Vervet monkey alarm calls: Semantic communication in a free-ranging primate. *Animal Behavior, 28,* 1070–1094.

Shaffer, D. R. (1979). *Social and personality development.* Monterey, CA: Brooks/Cole.

Shaw, M. E., & Costanzo, P. R. (1982). *Theories of* *social psychology* (2nd ed.). New York: McGraw-Hill.

Sheldon, W. H., & Stevens, S. S. (1942). *The varieties of temperament.* New York: Harper & Row.

Sheingold, K. (1973). Developmental differences in intake and storage of visual information. *Journal of Experimental Child Psychology, 16,* 1–11.

Shepard, R. N. (1978). The mental image. *American Psychologist, 33,* 125–137.

Shepher, J. (1971). Mate selection among second generation kibbutz adolescents and adults: Incest avoidance and negative imprinting. *Archives of Sexual Behavior, 1,* 293–307.

Sherman, P. (1977). Nepotism and the evolution of alarm calls. *Science, 197,* 1246–1253.

Shettleworth, S. J. (1975). Reinforcement and the organization of behavior in golden hamsters: Hunger, environment, and food reinforcement. *Journal of Experimental Psychology: Animal Behavior Processes, 104,* 56–87.

Short, J. F., Jr. (Ed.). (1968). *Gang delinquency and delinquent subcultures.* New York: Harper & Row.

Shucard, D. W. (April 1983). Cortical event-related potentials as probes of the functional organization of the brain. Invited address to the Western Psychological Association convention, San Francisco.

Sigall, H., & Ostrove, N. (1975). Beautiful but dangerous: Effects of offender attractiveness and nature of the crime on juridic judgment. *Journal of Personality and Social Psychology, 31,* 410–414.

Siqueland, E. R., & Lipsitt, L. P. (1966). Conditioned head-turning in human newborns. *Journal of Experimental Child Psychology, 3,* 356–376.

Skinner, B. F. (1948). *Walden two.* New York: Macmillan.

———. (1971). *Beyond freedom and dignity.* New York: Knopf.

Skodak, M., & Skeels, H. M. (1949). A final follow-up study of 100 adopted children. *Journal of Genetic Psychology, 75,* 85–125.

Slater, E., & Glithero, E. (1965). A follow-up of patients diagnosed as suffering from hysteria. *Journal of Psychosomatic Research, 9,* 9–13.

Slater, E., & Shields, J. (1969). Genetical aspects of anxiety. In M. H. Lader (Ed.), *Studies in anxiety: British Journal of Psychiatry Special Publication,* no. 3.

Sloane, R. B., Staples, F. R., Cristol, A. H., Yorkston, N. H., & Whipple, K. (1975). *Psychotherapy versus behavior therapy.* Cambridge: Harvard University Press.

Slobin, D. I. (1973). Cognitive pre-requisites for the acquisition of grammar. In C. A. Ferguson & D. I. Slobin (Eds.), *Studies of child language development.* New York: Holt, Rinehart & Winston.

Snow, C., & Ferguson, C. (Eds.). (1977). *Talking to children.* Cambridge, England: Cambridge University Press.

Snyder, S. H. (1977). Opiate receptors and internal opiates. *Scientific American, 236,* 44–56.

Solomon, R. L. (1980). The opponent-process theory of acquired motivation: The costs of pleasure and the benefits of pain. *American Psychologist, 35,* 691–712.

Solomon, R. L., & Corbit, J. D. (1973). An opponent-process theory of motivation: II. Cigarette addiction. *Journal of Abnormal Psychology, 81,* 158–171.

———. (1974). An opponent-process theory of motivation: I. Temporal dynamics of affect. *Psychological Review, 81,* 119–145.

Sontag, L. W., Baker, C. T., & Nelson, V. L. (1958). Mental growth and personality development: A longitudinal study. *Monographs of the Society for Research in Child Development, 23,* serial no. 68.

Spear, N. E., & Campbell, B. A. (Eds.). (1979). *Ontogeny of learning and memory.* Hillsdale, NJ: Lawrence Erlbaum.

Spearman, C. (1904). General intelligence objectively measured and determined. *American Journal of Psychology, 15,* 201–293.

Spencer, R. F., & Jennings, J. D. (Eds.). (1965). *The native Americans.* New York: Harper & Row.

Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs, 74,* 1–29.

Sperry, R. W. (1964). The great cerebral commisure. *Scientific American. 110,* 42–62.

———. (1969). A modified concept of consciousness. *Psychological Review. 76,* 532–536.

———. (1982). Some effects of disconnecting the cerebral hemispheres. *Science, 217,* 1223–1226.

Spitz, H. H. (1966). The role of input organization in the learning and memory of mental retardates. In N. R. Ellis (Ed.), *International review of research in mental retardation,* vol. 2. New York: Academic Press.

Stanley, W. C., Bacon, W. E., & Fehr, C. (1970). Discriminated instrumental learning in neonatal dogs. *Journal of Comparative & Physiological Psychology, 70,* 335–343.

Stern, D. N. (1974). Mother and infant at play: The dyadic interaction involving facial, vocal and gaze behaviors. In M. Lewis & L. A. Rosenblum (Eds.), *The effect of the infant on its caretaker.* New York: Wiley, 1974.

Sternberg, S. (1966). High-speed scanning in human memory. *Science, 153,* 652–654.

———. (1967). Retrieval of contextual information from memory. *Psychonomic Science, 8,* 55–56.

———. (1969). Memory-scanning: Mental processes revealed by reaction-time experiments. *American Scientist, 57,* 421–457.

Stevens, S. S. (1957). On the psychological law. *Psychological Review, 64,* 153–181.

———. (1961). To honor Fechner and repeal his law. *Science 133,* 80–86.

———. (1962). The surprising simplicity of sensory metrics. *American Psychologist, 17,* 29–39.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662.

Suomi, S. J., & Harlow, H. F. (1971). Abnormal social behavior in young monkeys. In J. Helmuth (Ed.), *Exceptional infant: Studies in abnormalities,* vol. 2. New York: Brunner/Mazel.

Symons, D. (1979). *The evolution of human sexuality.* New York: Oxford University Press.

Tanner, J. M. (1978). *Fetus into man: Physical growth from conception to maturity.* Cambridge: Harvard University Press.

Tanner, W. P., & Swets, J. A. (1954). A decision-making theory of visual detection. *Psychological Review, 61,* 401–409.

Tarpy, R. M. (1982). *Principles of animal learning and motivation.* Glenview, IL: Scott Foresman.

Teitelbaum, P. (1966). The use of operant methods in the assessment and control of motivational states. In W. K. Honig (Eds.), *Operant behavior.* New York: Appleton-Century-Crofts.

Temerlin, M. K. (1970). Diagnostic bias in community mental health. *Community Mental Health Journal, 6,* 110–117.

Terman, L. M. (1954). Scientists and nonscientists in a group of 800 gifted men. *Psychological Monographs, 68,* 1–44.

Terrace, H. S., Petito, C. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? *Science, 206,* 891–902.

Thigpen, C. H., & Cleckley, H. (1957). *The three faces of Eve.* New York; McGraw-Hill.

Thomas, A., & Chess, S. (1977). *Temperament and development.* New York: Brunner-Mazel.

Thomas, A., Chess, S., & Birch, H. G. (1970). The origin of personality. *Scientific American, 223,* 102–109.

Thomas, D. W., & Mayer, J. (1973). The search for the secret of fat. *Psychology Today, 7,* 74–79.

Thomas, M. H., Horton, R. W., Lippincott, E. C., & Drabman, R. S. (1977). Desensitization to portrayals of real-life aggression as a function of exposure to television violence. *Journal of Personality and Social Psychology, 35,* 450–458.

Thompson, R. F. (1975). *Introduction to physiological psychology.* New York: Harper & Row.

Thompson, R. F., & Spencer, W. A. (1966). Habituation: A model phenomenon for the study of neuronal substrates of behavior. *Psychological Review, 73,* 16–43.

Thompson, R. K. R., & Herman, L. M. (1977). Memory for lists of sounds by the bottle-nosed dolphin: Convergence of memory processes with humans? *Science, 195,* 501–502.

Thompson, W. R. (1957). Influence of prenatal anxiety on emotionality in young rats. *Science, 125,* 698–699.

Thompson, W. R., Grusec, J. E. (1970). Studies of early experience. In P. H. Mussen (Ed.), *Carmichael's manual of child psychology.* New York: Wiley.

Thurstone, L. L. (1938). Primary mental abilities. *Psychometric Monographs,* no. 1. Chicago: University of Chicago Press.

Tiger, L. (1969). *Men in groups.* New York: Random House.

Tiger, L., & Fox, R. (1971). *The imperial animal.* New York: Holt, Rinehart and Winston.

Tinbergen, N. (1951). *The study of instinct.* New York and London: Oxford University Press.

———. (1972). *The animal in its world,* vol. 2. Cambridge: Harvard University Press.

Tizard, B., & Hodges, J. (1978). The effect of early institutional learning on the development of eight-year-old children. *Journal of Child Psychology and Psychiatry, 19,* 99–118.

Tizard, B., & Rees, J. (1975). The effect of early institutional rearing on the behavior problems and affectional relationships of four-year-old children. *Journal of Child Psychology and Psychiatry, 16,* 61–73.

Tizard, J., & Tizard, B. (1971). The social development of two-year-old children in residential nurseries. In H. E. Schaffer (Ed.), *The origins of human social relations.* London: Academic Press.

Tolman, E. C. (1932). *Purposive behvior in animals and men.* New York: Appleton-Century-Crofts.

———. (1949). There is more than one kind of learning. *Psychological Review, 56,* 144–155.

Trehub, S. E. (1979). Reflections on the development of speech perception. *Canadian Journal of Psychology, 33,* 368–381.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology, 46,* 35–57.

Truax, C. B. (1966). Reinforcement and nonreinforcement in Rogerian psychotherapy. *Journal of Abnormal and Social Psychology, 71,* 1–9.

Tryon, R. C. (1940). Genetic differences in maze-learning ability in rats. *Thirty-ninth yearbook of the National Society for the Study of Education.* Bloomington, IN: Public School Publishing, 111–119.

———. (1942). Individual differences. In F. A. Moss (Ed.), *Comparative psychology.* New York: Prentice-Hall.

Tucker, D. M. (1981). Lateral brain function, emotion, and conceptualization. *Psychological Bulletin, 89,* 19–46.

Tulving, E., & Thompson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review, 80,* 352–373.

Turnbull, C. M. (1961). *The forest people: A study of the Pygmies of the Congo.* New York: Simon & Schuster.

Ullmann, L. P., & Krasner, L. (1975). *A psychological approach to abnormal behavior.* Englewood Cliffs, NJ: Prentice-Hall.

Underwood, B., & Moore, B. (1982). Perspective-taking and altruism. *Psychological Bulletin, 91,* 143–173.

Ungerer, J. A., Brody, L. R., & Zelazo, P. R. (1978). Long-term memory for speech in 2- to 4-week-old infants. *Behavior and Child Development, 1,* 177–186.

Uzgiris, I. C., & Hunt, J. McV. (1975). *Assessment in infancy: Ordinal scales of psychological development.* Urbana, IL: University of Illinois Press.

Valenstein, E. S. (1973). *Brain control: A critical examination of brain stimulation and psychosurgery.* New York: Wiley.

———. (1980). Historical perspective. In E. S. Valenstein (Ed.), *The psychosurgery debate.* San Francisco: Freeman.

Valle, R. S., & King, M. (1978). *Existential-phenomenological alternatives for psychology.* New York: Oxford University Press.

Van Lawick-Goodall, J. (1967). *My friends the chimps.* Washington, D.C.: National Geographic.

———. (1968). The behavior of free-living chimpanzees in the Gombie Stream area. *Animal Behavior Monographs, 1,* 161–311.

———. (1971). *In the shadow of man.* New York: Dell.

van Praag, H. M. (1978). *Psychotropic drugs: A guide for the practitioner.* New York: Brunner/Mazel.

Venables, P. H. (1977). The electrodermal psychophysiology of schizophrenics and children at risk for schizophrenia: Controversies and developments. *Schizophrenia Bulletin, 3,* 28:48.

Venables, P. H., & Bernstein, A. S. (1983). The orienting response and psychopathology: Schizophrenia. In D. Siddle (Ed.), *Orienting and habituation: Perspectives in human research.* New York: Wiley.

Wade, N. (1976). IQ and heredity: Suspicions of fraud becloud classic experiment. *Science, 194,* 916–919.

Wahler, R. G. (1967). Infant social attachments: A reinforcement theory interpretation and investigation. *Child Development, 38,* 1079–1088.

Walk, R. D. (1966). The development of depth perception in animals and human infants. *Monographs of the Society for Research in Child Development, 31,* 82–108.

———. (1981). *Perceptual development.* Monterey, CA: Brooks/Cole.

Wallace, B., & Fisher, L. E. (1983). *Consciousness and behavior.* Boston: Allyn & Bacon.

Wallas, G. (1926). *The art of thought.* New York: Harcourt, Brace, & World.

Walster, E., Berscheid, E., & Walster, G. W. (1973). New directions in equity research. *Journal of Personality and Social Psychology, 25,* 151–176.

Walster, E., Walster, G. W., & Bersceid, E. (1978). *Equity: theory and research.* Boston: Allyn & Bacon.

Walster, E., Walster, G. W., & Traupmann, J. (1978). Equity and premarital sex. *Journal of Personality and Social Psychology, 36,* 82–92.

Waring, M., & Ricks, D. (1965). Family patterns of children who become adult schizophrenics. *Journal of Nervous and Mental Disease, 140,* 351–364.

Waters, E., Wippman, J., & Sroufe, L. A. (1979). Attachment, positive affect, and competence in the peer group: Two studies in construct validation. *Child Development, 50,* 821–829.

Watson, J. B. (1913). Psychology as a behaviorist views it. *Psychological Review, 20,* 158–177.

———. (1930). *Behaviorism.* New York: W. W. Norton.

Watson, J. B., & Rayner, R. (1920). Conditioned emotional reactions. *Journal of Experimental Psychology, 3,* 1–14.

Watson, R. I. (1978). *The great psychologists* (4th ed.). Philadelphia: Lippincott.

Wechsler, D. (1958). *The measurement and appraisal of adult intelligence.* Baltimore: Williams & Wilkins.

Wecker, S. C. (1963). The role of early experience in habitat selection by the prairie deermouse, *Peromyscus maniculatus bairdi. Ecological Monographs, 33,* 307–325.

Weinberg, G. H., & Schumaker, J. A. (1969). *Statistics: An intuitive approach.* Belmont, CA: Brooks/Cole.

Weintraub, D. J., & Walker, E. L. (1966). *Perception.* Belmont, CA: Brooks/Cole.

Weiss, L., & Lowenthal, M. F. (1975). Life-course perspectives on friendship. In M. F. Lowenthal, M. Thurnher, & D. Chiriboga (Eds.), *Four stages of life.* San Francisco: Jossey-Bass.

Weizmann, F., Cohen, L. B., & Pratt, J. (1971). Novelty, familiarity, and the development of infant attention. *Developmental Psychology, 4,* 149–154.

Wetherby, B., & Baumeister, A. A. (1981). Mental retardation. In S. M. Turner, K. S. Calhoun, & H. E. Adams (Eds.), *Handbook of clinical behavior therapy.* New York: Wiley.

Wetherford, M. J., & Cohen, L. B. (1973). Developmental changes in infant visual preferences for novelty and familiarity. *Child Development, 44,* 416–424.

Whalen, R. E., & Simon, N. G. (1984). Biological motivation. *Annual Review of Psychology, 35,* 257–276.

Whitehurst, G. J. (1982). Language development. In B. B. Wolman (Ed.), *Handbook of developmental psychology.* Englewood Cliffs NJ: Prentice-Hall.

Whitman, C. O. (1919). The behavior of pigeons. *Publication of the Carnegie Institute, 257,* 1–161.

Whorf, B. L. (1956). *Language, thought, and reality.* New York: Wiley.

Wickelgren, W. A. (1979). *Cognitive psychology.* Englewood Cliffs NJ: Prentice-Hall.

———. (1981). Human learning and memory. *Annual Review of Psychology, 32,* 21–52.

Wicklund, R. A., & Brehm, J. W. (1976). *Perspectives on cognitive dissonance.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Willey, B. (1951). The touch of cold philosophy. In R. F. Jones (Ed.), *The seventeenth century: Studies in the history of English thought and literature from Bacon to Pope.* Stanford: Stanford University Press.

Williams, D. R., & Williams, H. (1969). Automaintenance in the pigeon: Sustained pecking despite contingent nonreinforcement. *Journal of the Experimental Analysis of Behavior, 12,* 511–520.

Wilson, E. O. (1975). *Sociobiology: The new synthesis.* Cambridge: Harvard University Press.

———. (1978). *On human nature.* Cambridge: Harvard University Press.

Wilson, G. T. (1978). Aversion therapy for alcoholism: Issues, ethics, and evidence. In G. A. Marlatt & P. E. Nathan (Eds.), *Behavioral assessment and treatment of alcoholism.* New Brunswick, NJ: Center for Alcohol Studies.

Wilson, G. T., & Lawson, D. M. (1976). Expectancies, alcohol, and sexual arousal in male social drinkers. *Journal of Abnormal Psychology, 85,* 587–594.

Wilson, G. T., Leaf, R., & Nathan, P. E. (1975). The aversive control of excessive drinking by chronic alcoholics in the laboratory setting. *Journal of Applied Behavior Analysis, 8,* 13–26.

Wilson, G. T., & O'Leary, K. D. (1980). *Principles of behavior therapy.* Englewood Cliffs, NJ: Prentice-Hall.

Wilson, J. G. (1972). Environmental effects on development—teratology. In N. S. Assali (Ed.), *Pathophysiology of gestation.* New York: Academic Press.

Winer, G. A. (1980). Class-inclusion reasoning in children: A review of the empirical literature. *Child Development, 51,* 309–328.

Wingfield, A., & Byrnes, D. L. (1981). *The psychology of human memory.* New York: Academic Press.

Wissler, C. (1901). The correlation of mental and physical traits. *Psychological Monographs, 3,* serial no. 16.

Witelson, S. (1976). Sex and the single hemisphere: Specialization of the right hemisphere for spatial processing. *Science, 193,* 425–427.

———. (1977). Sex differences in the neurology of cognition: Psychological, social, educational, and clinical implications. In E. Sullerot & C. Escoffier (Eds.), *Le Fait Féminin.* Paris: Fayard.

Wohlwill, J. F. (1960). Developmental studies of perception. *Psychological Bulletin, 57,* 249–288.

Wolff, P. H. (1969). The natural history of crying and other vocalizations in early infancy. In B. Foss (Ed.), *Determinants of infant behavior,* vol. 4. London: Methuen.

Woodworth, R. S. (1918). *Dynamic psychology.* New York: Columbia University Press.

Wooley, S. C., Wooley, O. W., & Dyrenforth, S. R. (1979). Theoretical, practical, and social issues in behavioral treatments of obesity. *Journal of Applied Behavior Analysis, 12,* 3–25.

Wortman, C. B., & Loftus, E. F. (1981). *Psychology.* New York: Knopf.

Wrangham, R. W. (1975). The behavioral ecology of chimpanzees in Gombe National Park, Tanzania (Ph.D. diss. Cambridge University).

Wundt, W. (1874). *Grudzüge der physiologischen psychologie.* Liepzig: Engelmann.

Yonas, A., Petterson, L,., & Lockman, J. J. (1979). Young infants' sensitivity to optical information for collision. *Canadian Journal of Psychology, 33,* 268–276.

Yonas, A., Bechtold, A., Frankel, D., Gordon, R., McRoberts, G., Norcia, A., & Sternfels, S. (1977). Development of sensitivity to information for impending collision. *Perception and Psychophysics, 21,* 97–104.

Zola-Morgan, S., & Squire, L. R. (1982). The neuroanatomy of amnesia: Amygdala-hippocampus versus temporal stem. *Science, 218,* 1337–1339.

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